JULY 1951

MINING ENGINEERING

Jet Piercing - - - -

key to

TACONITE DEVELOPMENT

See Pages 571, 585

For mill pulp

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Performance

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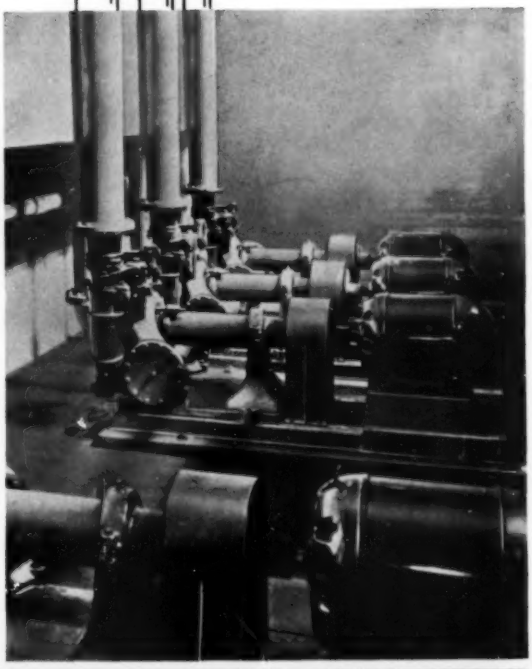
A large Western copper mill depends on this bank of 8" WILFLEY Rubber Lined Sand Pumps for handling mill pulp on an economical basis. →



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Incorporating Mining and Metallurgy, Mining Technology and Coal Technology

VOL. 3 NO. 7 JULY, 1951

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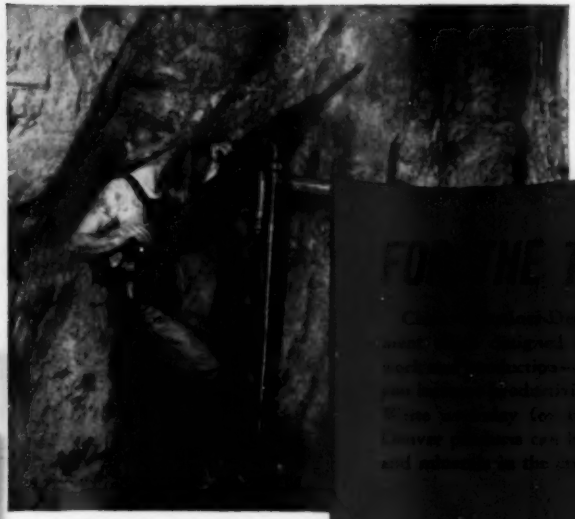
COVER: The Linde Air Products Jet-Piercing machine, symbol of vast new developments that are to take place on the Minnesota iron ranges, and key to those developments. Machines like these will penetrate taconite rock at 90 to 150 ft per shift, and make possible the mining of 30 to 40 million tons of iron ore a year from the eastern end of the Mesabi. See Pp. 571 and 585 for the full story.



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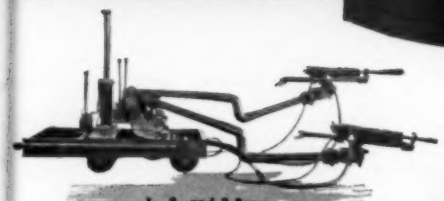

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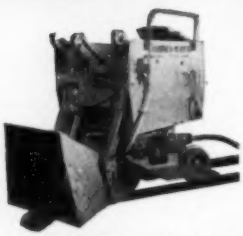

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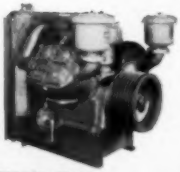

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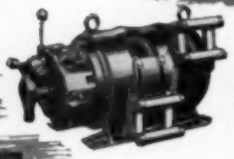

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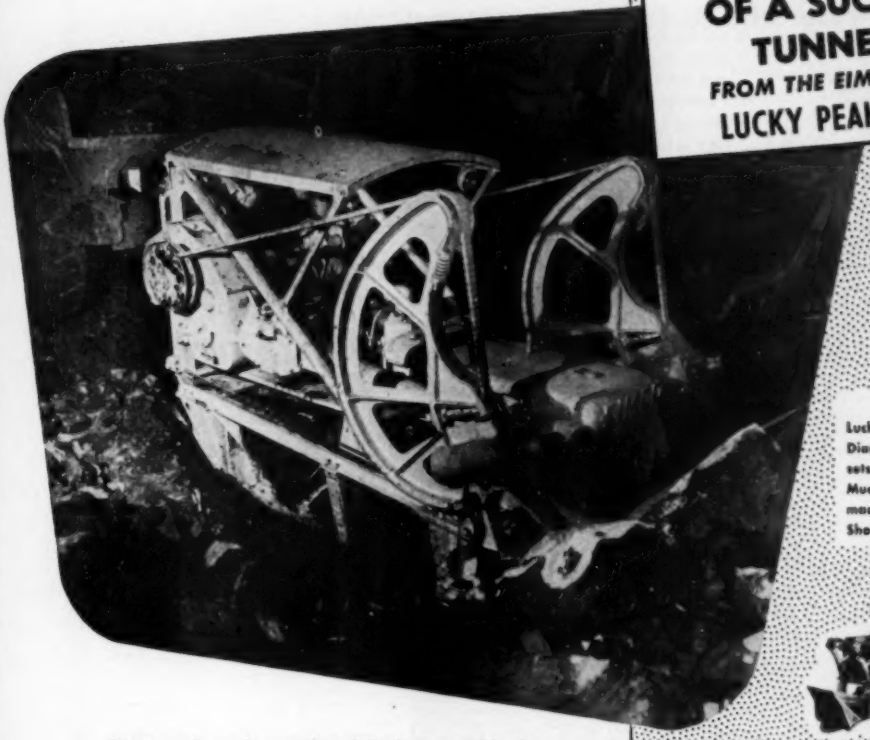
FROM THE EIMCO FILE T256

LUCKY PEAK TUNNEL



Specifications

Lucky Peak tunnel 1140' long. Diam. 29'6" inside circular steel sets. Average round 8' deep. Mucking time 3 hours. Mucking machine — Eimco 104 RockerShovel.

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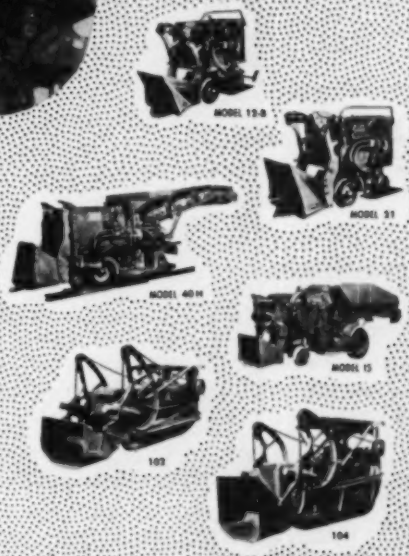

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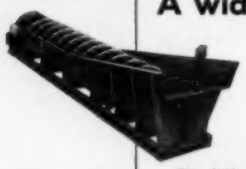

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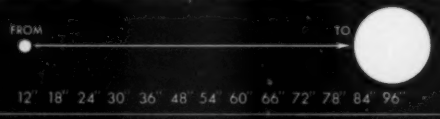
The following table shows a partial breakdown of more than 2,000 standard WEMCO Classifier models:

OPTION	DESCRIPTION	REMARKS
1 SPIRAL DIAMETERS		A right diameter for every job, giving better balance between sand conveyance and pool area requirements.
2 SPIRAL PITCH		"S-H" (Special Helix) advanced pitch design on all models, giving up to 100% greater raking capacity compared to other designs.
3 SPIRAL LENGTH		Length furnished to fit exact needs of each job—correct lengths for closed circuiting—adequate drainage deck length for dewatering.
4 TANK STYLE		Tank styles to fit the characteristics of the material and the separation to be made—up to 25% greater "effective" pool area than other units.
5 POOL DEPTH		Generally Series 90 is used for 48 mesh and coarser separations, Series 125 for 48 mesh to 150, and Series 150 for 100 to 325 mesh separation.
6 ASSEMBLIES		Duplex units give nearly double the capacity of simplex units, but require less floor space than two separate units.
7 LIFTING DEVICE		Smooth, powerful hydraulic action is usually preferred to the older style screw lift.

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Here's something more . . .

Case-histories No. 1 and No. 2 (previously published in this series) gave service tests involving the crushing of millions of tons of ore. Here are further cases taken from actual ore-grinding practice—you can rely on these data.

Case No. 3

Tests in Colorado, 1939: Molybdenite ore—quartz and feldspar, principal abrasives.

Service: "98" Marcy grate discharge type ball mills grinding $\frac{3}{8}$" siliceous ore to minus 100 mesh. Mill speed 20 rpm: balls charged were 3" dia.

Comparison: Lifter type clamp bars in low discharge grates, over a six-months period. Four bars of austenitic manganese steel together with four bars of chromium-molybdenum steel, normalized and tempered to 375 Brinell. The bars were not worn flush with the grates when they were removed for weighing.

Results: Four manganese steel clamp bars lost 166lb. weight
Four Cr-Mo steel clamp bars lost ... 144lb. weight

In this test the manganese steel bars wore 15% faster than the chrome-molybdenum steel.

Case No. 4

Tests at a mine grinding low-grade copper ore, 1945-1949.

Service: Marcy 10′ × 10½′ grate discharge type ball mills grinding minus $\frac{3}{4}$"feed to 84% minus 100 mesh. Mill speed 18 rpm: balls charged were 2½" and 2" dia.

Comparison: Several sets of austenitic manganese steel liners, concurrently with one set of high carbon chromium-molybdenum steel liners normalized and tempered to 350Brinell.

Liner Type: Shell (barrel) liners, ship lap type; weight 47,000 lb. approx. per set.

Results:	*Tonnage ground*	*Life-Days*
Manganese steel, average...	593,344	337
Cr-Mo Steel	667,308	379

The chrome-molybdenum steel liners wore 12% longer than the manganese steel liners.

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Meet The Authors

D. H. FLEMING

R. L. BROWN

A. C. FIELDNER

J. J. CALAMAN

R. L. Brown (*Economic Significance of Recent Technologic Research on Solid Fuels*, P. 597) is a widely known coal technologist and a pioneer in the development of new products from coal tar chemicals. He has been chief of the Bureau of Mines fuels and explosives division, coal branch, for more than 3 years, supervising the Bureau's research in the mining, preparation, carbonization, and gasification of coal, as well as other projects. Dr. Brown began his career with Inland Steel's coke plant laboratory, and later went with the Koppers Co.'s laboratories at the Mellon Institute. He served as an officer in France during World War I, returned to the Koppers Co. for several years, and then headed the Bureau of Mines' organic chemical section at Pittsburgh. Work on resinous deposits hindering the manufactured gas industry earned him the American Gas Assn.'s Beal Award in 1924. From 1928 to 1937 he supervised research for Allied Chemical & Dye's Solvay process division, and then became research director for Pennsylvania Salt. Dr. Brown was educated at Missouri State Teachers College, University of Missouri, and the University of Chicago, where he took his Ph.D. in chemistry.

K. S. Benson (*"Depletion" in Federal Income Taxation of Mines*, P. 512) an attorney for Pickands Mather and Co., has been with that company for 4 years. He attended Dartmouth, Yale, and Western Reserve, taking B.S. and L.L.B. degrees, and was elected to Phi Beta Kappa and the Order of the Coif. Mr. Benson entered the U. S. Army as a private in 1941, and was discharged as a major in 1946. He served overseas in the Philippines and Korea with the Army's finance department. Mr. Benson is a member of Theta Delta Chi and Phi Delta Phi, the last-named a legal fraternity.

D. H. Fleming (*Production Jet-Piercing of Blastholes in Magnetic Taconite*, P. 585) has been with Linde Air Products since 1941, working on projects such as jet piercing, armor ship plate cutting, the Manhattan Project, powder cutting and scarfing of stainless steels, metallurgical oxygen, and various new process developments. He took his B.S. and M.S. in mechanical engineering from MIT the same year he joined Linde. Mr. Fleming is an AIME member and an associate member of Sigma Xi.

M. M. Fine (*Concentration of the Complex Copper - Lead - Cobalt - Nickel Ores of Southeast Missouri*, P. 602) heads the Bureau of Mines' mineral dressing branch at Rolla, Mo. After taking his B.S. from Washington University in 1935, he worked for the Laclede Gas Co., and then joined the Bureau as a chemist. Mr. Fine is an AIME member, and has presented three other papers before the Institute.

J. J. Calaman (*co-author with Mr. Fleming*, P. 585) joined the Linde Air Products research laboratories in 1943 as a research engineer at Tonawanda, N. Y. For the past two years he has been with the company's Newark, N. J. development laboratories, working on such projects as jet piercing. He holds a B.S. in chemical engineering from Bucknell, is a member of AIME, AIChE, Alpha Chi Sigma, Pi Mu Epsilon, and the engineers club of Northern Minnesota.

E. P. Pfleider (*Mining Needs Research*, P. 572), who now heads the mining department at the University of Minnesota, brought to his present job a wealth of experience in mining. After taking his E.M. from the University of Minnesota, he worked for Freeport Sulphur in Louisiana and Texas, then spent 3 years as a chief engineer and mine foreman in Bolivia. Returning to Freeport, he was superintendent at their manganese and nickel mines in Cuba from 1937-1943. From 1943 to 1946 he was in the U. S. Navy. Mr. Pfleider, an AIME member, has been active in Institute affairs, serving as Chairman of the Mining Subdivision's Papers and Programs Committee, and as Vice-Chairman of the Minnesota Section.

A. C. Fieldner (*Economic Significance of Recent Technologic Research on Solid Fuels*, P. 597) chief fuels technologist for the Bureau of Mines in Washington, has been in Government work since 1907, when he started as a chemist with the USGS. He was at the Pittsburgh Station of the Bureau for 17 years, serving as superintendent there for 6 years. Then he spent 9 years as chief engineer of the experiment stations division in Washington, 6 years as head of the technologic branch, and 9 years as chief of the fuels and explosives division. He has been honored by the University of Alabama (D.Sc., 1936) and by Ohio State (D.Sc., 1944) and has received the Melchett Medal from Great Britain's Institute of Fuels. In 1946, the joint AIME-ASME Percy Nicholls Award was conferred upon him. An AIME member, Dr. Fieldner has contributed three other papers to Institute literature.

J. Paul Trueblood (*Computing Survey Notes With Traverse Tables*, P. 581), now with the Bureau of Mines special minerals division, has been with the Bureau of Reclamation, Braden Copper Co., U. S. Vanadium Corp., Howe Sound, and has worked in Alaska and various properties in Idaho. He's a registered professional engineer in the State of Idaho, and a lieutenant in the U. S. Naval Reserve.

W. E. Brown (*Concentration of the Complex Copper - Lead - Cobalt - Nickel Ores of Southeast Missouri*, P. 602), formerly a heat treat foreman for the Excello Aircraft Co., and a metallurgist for the Bureau of Mines, has been with the Humphreys Investment Co. as a metallurgical engineer since 1947. He holds B.Sc. degrees in both mining and metallurgical engineering from the Michigan College of Mining & Technology. An AIME member, Mr. Brown co-authored "Humphreys Spiral Concentrator on Mesabi Range Ores," which was presented at the 1949 Annual Meeting.

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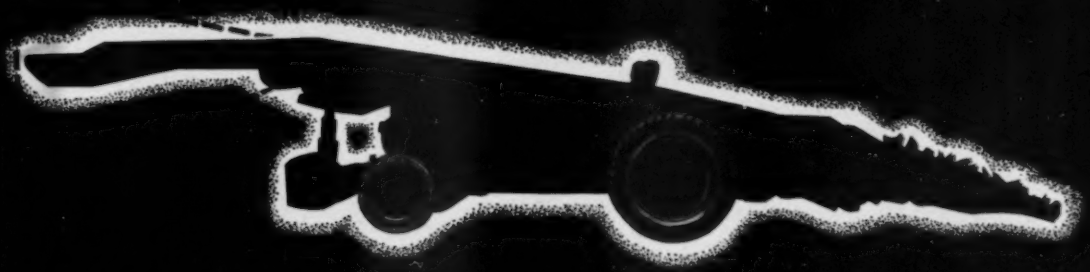

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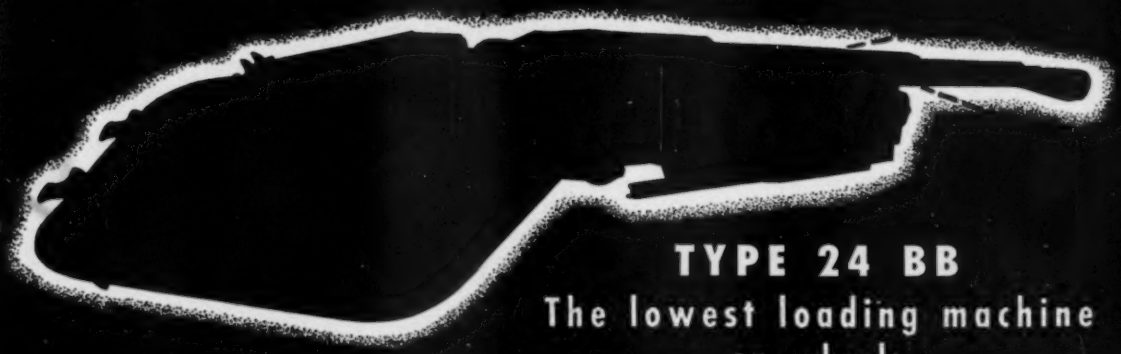

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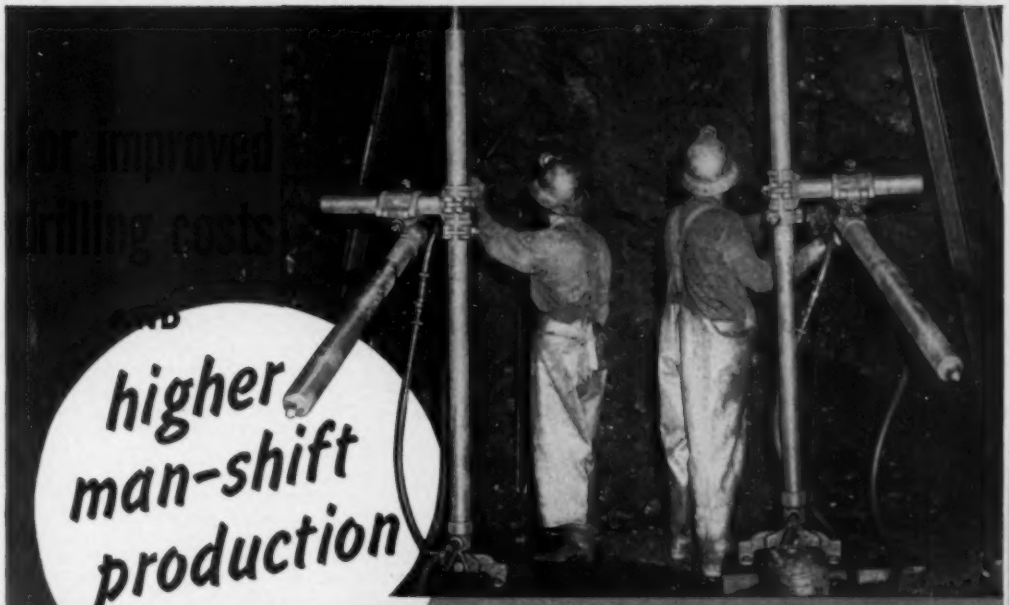

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Le Roi-CLEVELAND Air-feed Sinker Drills are available in two sizes — the HC10R using the popular 45-lb. U10 drill and the HC23R with the 3½-inch bore H23 machine. Write today for complete information.

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MEN AVAILABLE

Engineer, 37, married, 3 children; B.S. in Metallurgy. Presently and for past eight years mill superintendent for 750 ton per day concentrator. Four years' experience ore testing laboratory. Available August. Only interested western United States. M-630.

Mining Engineer with many years' experience exploration, testing and developing, and operating metallic and non-metallic properties, domestic and foreign. Available August for responsible connection, domestic or foreign. Married, good health, employed. M-631.

POSITIONS OPEN

Junior Engineer, 26-30, metallurgical or mining graduate, with mining and milling equipment experience, to assist in office engineering covering correspondence, purchasing, specifications, expediting, etc. Occasional trips. Salary, $4200-$4500 a year. Location, New York, N. Y. Y5551.

Engineers. (a) Assistant to General Manager, graduate, with considerable experience in management. Knowledge of Spanish desirable. (b) Metallurgical Engineer, graduate, with considerable experience in milling and research, capable of directing the operations of the heavy medium and gravity plants, and in advisory capacity at other mills. Should be able to direct and carry on research in the beneficiation of tin ores in the experimental laboratory. (c) Superintendent of the sink and float plant, graduate, with 5 or more years' experience in milling. Should be mechanically inclined and have some experience as mill superintendent elsewhere. Should have working knowledge of Spanish and be able to handle Latin American labor. (d) Junior Metallurgists, graduates, with some experience in milling practice as well as laboratory research. Location, South America. Y5549.

Metallurgist for position as mill superintendent for a copper company in New England. Y5542.

Mining Engineer with at least 10 years' experience with nonferrous, underground metal mining, including both operating experience and either examination or exploration experience. Salary to start, $5750-$6750 a year depending on qualifications. Transportation of family and household goods paid. Location, Alaska. Y5527.

Sales Engineer, about 30, mechanical graduate, with some sales experience, for sale of industrial oil to paper mills, automotive manufacturers, heavy industry, etc., for major oil company. Location, Wisconsin. Y5480.

Instructor in mining engineering, to teach mine plant design, mine evaluation, mine ventilation, mine surveying, and coal mining methods. Position starts September 15, 1951. Location, Alaska. Y5470.

Chief Engineer, 30-40, thoroughly experienced with background in mine layout, mill design, both new construction and revamping; structural steel and concrete work, to head up engineering department of nonmetallic underground mining and milling operation of medium size. Should be able to pass state examination for licensed civil engineer. Housing available. Location, West. Y5449(a).

Mining Engineer, graduate, B.S. in mining engineering, with 3 to 8 years' experience. Practical underground experience, nonmetallic or metallic mining necessary, preferably in open-stope type operation. Should possess a good working knowledge of rock drilling equipment and handling of explosives. Capable of training and handling men for underground work. Salary $4800-$5700 a year. Location, West Virginia. Y5448.

Superintendent for iron ore concentration plant. Must have 5 or more years' experience in supervising beneficiation plants. Must have knowledge of modern ore-dressing processes and equipment. Will supervise operation of large, modern iron ore concentrator. Salary open. Location, Minnesota. T7759.

POSITION WANTED

A graduate mining engineer, age 47, 25 years' general mining and administrative experience with American and British interests Northern Rhodesia and West Africa seeks appointment.

Box F-13 MINING ENGINEERING

CHIEF ENGINEER

Thoroughly experienced engineer with background of mine layout, mill design (both new construction and revamping), structural steel and concrete work, to head up engineering department of nonmetallic underground mining and milling operation of medium size. Preferred age 30 to 40. Should be able to pass State examination for licensed civil engineer. Housing available. Location western state. When replying give complete experience record and state salary expected.

Box E-9, MINING ENGINEERING

DRAFTSMAN

With experience in plant layout and detail. Must be good in concrete and steel structure detail and with knowledge of dry conveying equipment. Salary $375.00 per month. Single status preferred. Location western state.

Box E-10, MINING ENGINEERING

CIVIL SERVICE EXAMINATION
GEOLOGISTS—$4600 to $7600
(Grades GS-9 to GS-13)

88. Optional fields: mineralogy and petrology, geomorphology and glaciology, geology of metallic and nonmetallic mineral deposits, sedimentation, stratigraphy, paleontology, ground water geology, geology of fuels, general geology, engineering geology, mining geology. *Basic requirements:* B.S., with courses in geology and 30 hours of practical work; *or* 30 semester hr of geology courses plus geological experience to provide background approximating that of college graduate. Applications available at post offices, or Civil Service Commission Regional offices. Announcement No. 287. Open until further notice.

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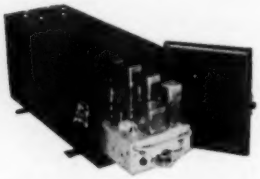
F-M Mine Communication

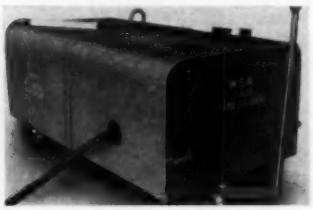
An improved carrier-current FM transmitter-receiver for mine communications has been developed by the General Electric Co. The equipment provides two-way voice communication between a fixed mine station and a locomotive, between two



fixed stations, or between two locomotives. A 6-v automobile-type storage battery, charged from a dc trolley line through dropping resistors, or from a motor-generator set on the locomotive, provides power for the radio equipment. The equipment is housed in a heavy-gage steel enclosing case equipped with shock and vibration mount. It operates at a fixed frequency of 100 kc. The transmitter-receiver is a plug-in unit automatically making all connections with power supply, control, and tuning. **Circle No. 1**

Steam Cleaner For Mining Equipment

A time- and labor-saving all-electric steam cleaner for cleaning mining machinery is now being offered by the Mine Safety Appliances Co. The new device, approved by the Bureau of Mines for use in coal mines, uses a non-flammable powdered cleaner, dissolved in hot water. Grease and dirt



are removed from machinery by a blast of the steam solution, which has passed through an electrically heated manifold in the machine. A 20-gal tank holds enough of the cleaner in solution for 4 hours of steady operation. Three types of nozzles are supplied, two for cleaning flat surfaces, and the other for irregular surfaces. Automatic controls permit operation without further attention after the flow of cleaner has begun. The cleaners weigh about 800 lb, have an overall height of 32 in., and operate at pressures from 100 to 120 psi. In addition to the approved type, a standard model is available for use in fresh air and underground repair shops. **Circle No. 2**

Link-Belt Offers New Oscillating Trough Conveyor

A new oscillating trough-type conveyor for handling a variety of loose bulk materials at moderate capacities has been announced by Link-Belt. The "Flexmount" design features the use of a one-piece metal trough with high sides, supported on one-piece flexible members which function as springs in absorbing the energy of trough movement after each stroke. The trough is 4 in. deep, furnished in standard widths of 8 to 24 in., and is made of No. 10 or 12 gage stainless or corrosion resisting steel. Troughs in lengths up to 100 ft can be furnished, and dividers can be installed to convey several materials simultaneously. **Circle No. 3**

Kennametal Buys Nevada Scheelite Co.

Kennametal, Inc., producers of hard carbide metals and products for the mining industry, has purchased the Nevada Scheelite Co., with mines and mill near Rawhide, Nev. Kennametal hopes to increase by 50 pct the output of concentrates from the mine, and anticipates effective utilization because of the company's knowledge of both tungsten mining and the metallurgy and end uses of the metal. The demand for Kennametal continues to exceed supply and output at the company's Latrobe, Pa. plant. Production at Nevada Scheelite is less than one-third that presently used at Latrobe. **Circle No. 4**

Water-Filled Tires Prove Effective Underground

Increases in tire life and low operating costs for tires used in underground mining and run at low speeds (less than 5 mph) can be effected by substituting 100 pct water filling for air, tests by Goodyear Tire & Rubber have shown. With the new method, adequate pressure is maintained constantly, since internal pressure varies with the load. Tire flexing is thus kept within reasonable limits. Bounce is less and rolling resistance is decreased. Operators report that water-filled tires ride and steer better than the air-inflated ones. Inflation equipment is eliminated, and there is no seepage as is possible with use of air. A special high-pressure positive-displacement pump, which can be obtained from shuttle car manufacturers, is used to inflate the tires. **Circle No. 5**

Small Geiger Counter

Another entrant in the Geiger counter field is the "Snooper," manufactured by Precision Radiation Instruments, Inc. Its small size is a lead-

ing feature, and makes it amenable to carrying in the hand or in a hip pocket. Designed to fill the need for a low-priced Geiger counter for civilian defense as well as prospecting, the "Snooper" sells for less than $25. It's in a plastic case, is operated by an ordinary flashlight battery, and is supplied with an earphone and a radioactive sample. A miniature amplifier creates a loud signal when radioactivity is encountered. The "Snooper" measures 1½ x 3 x 5 in., and weighs 1¼ lb. **Circle No. 6**

Rail Flaw Detector

A portable ultrasonic flaw detector, especially useful for testing railroad rails, is being offered by Branson Instruments, Inc. It discovers hidden de-

fects in critical locations such as the area within join-bar limits, switches, tunnels, grade crossings, etc. Ultrasonic resonance generates a tone in the earphones worn by the operator, with a perfect rail causing resonance at a frequency of 1000 cycles per sec. The presence of flaws is indicated by a change in the pitch of the signal. Controls are pre-set except for the on-off switch. The instrument, weighing 12 lb, is housed in a canvas bag. Power is supplied by batteries. **Circle No. 7**

Free Literature

(8) SAND-FILTER CLARIFIER: Bulletin #30-B issued by *Hardinge Co., Inc.* covers its line of sand-filter clarifiers. Quite different from the automatic backwash sand filter, the filter-clarifier uses a spiral scraper that takes a cut off the sand bed when the filter rate decreases. It is used in processes where a crystal-clear filtrate is desired. This bulletin discusses operating principles, typical performance data, capacities and advantages. The main advantages are: The tank affords storage for the solution prior to filtering, a crystal-clear filtrate is secured, and an inexpensive filter medium can be used.

(9) ARTIFICIAL RESPIRATOR: Bulletin #Ch-2 issued by *Mine Safety Appliances Co.* The Pneolator uses intermittent positive pressure to provide safe, uniform lung ventilation in cases of respiratory failure. In operation, it automatically inflates the lungs with the right amount of oxygen and at the right pressure for the unconscious victim's physical requirements. No suction is employed, exhalation takes place by normal passive return of respiratory muscles in the lungs from the expanded state of inhalation. Compact, and weighing only approximately 47 lb complete, the Pneolator is contained in a strong, light, fiberglas carrying case.

(10) BELTING: An informative 16-page booklet on belting, which includes practical maintenance suggestions and engineering data, has been released by *E. F. Houghton & Co.* This booklet contains information on making belts endless on pulleys, types of motor bases, fasteners, lacings, cement, preservatives and repairing belts. Several helpful belt formulas are included in the engineering data section, along with a table on hp rating of shafting of various diameters at various speeds. The patented tread feature and the special mineral tannage used in the manufacture of Vim Tred belts are described in photographs and diagrams.

(11) ORE CRUSHER: Operation, application and specifications of the *Allis-Chalmers* Hydrocone crusher, available with or without wobble plate feeder, are covered in a new 32-page bulletin. The crusher is available in cone sizes from 22 to 84-in. diam, with coarse, intermediate or fine crushing chambers or with special chambers designed to meet varying operating requirements. Graphs and tables governing feed size, capacity and product required and operating conditions are provided to permit selecting a Hydrocone crusher and its motor for a specific job.

(12) LIQUEFIED GASES: Included in an *Arthur D. Little, Inc.*, booklet are brief descriptions of the ADL Collins helium cryostat, hydrogen liquefier, liquid oxygen generator, helium refrigerator and liquid-oxygen pump—all applicable to work with liquefied gases or to low temperature investigations. Also shown are the non-contaminating gas holder, air cooler (for cooling electronic gear) and the ADL high flux density electromagnet.

(13) COUPLINGS: Geared power transmission applications are shown with line drawings and photographs in brochure released by *Falk Corp.* Uses of speed reducers, couplings, gear and Motoreducers in specific industries are illustrated.

(14) ATOMIC PROTECTION: *Mine Safety Appliances Co.'s* Booklet #G-10 is of interest to industries directly concerned with the atomic energy field, as well as the increasing number of industrial plants using radioactive isotopes. This booklet is concerned with problems of air and surface contamination involving radioactive or toxic contaminants. Described in the booklet are respiratory protective equipment, air sampling equipment, ventilation accessories, protective clothing, materials for contamination, control, automatic artificial respiration instruments, and oxygen therapy equipment.

(15) DIESEL ENGINES: Two new 16-page booklets have been issued covering Cummins and General Motors power equipment manufactured by the *Euclid Road Machinery Co.* These list by model number the various diesel engines and the Euclid equipment in which they are available. Specifications for rear-dump and bottom-dump hauling units, scrapers and loaders are included, as are lists of engine dealers and distributors in the United States and Canada.

(16) WIRES AND CABLES: A comprehensive booklet has just been published by *General Electric* in which are listed a complete line of wires and cables for coal and metal mining applications. A full description of mine power cable, mining machine cable, mine locomotive cable, specifically designed and engineered to meet the rugged conditions of strip and underground mining operations is given. This booklet also contains information on splicing and terminating methods, in addition to detailed specification data for each type of cable.

(17) LIME HYDRATORS: Bulletin 49 describes the *Hardinge Co., Inc.* lime hydrators. It describes the theory of lime hydration, as well as construction details, dimensions and capacities of Hardinge hydrators. Additional equipment is also discussed: vertical and horizontal rotary lime kilns, tube mills for hydrate grinding, conical mills for limestone reduction, continuous rotary dryers, and regulating feeders.

(18) RECORDING METERS: A new 28-page bulletin describing recently-announced line of 500 recording voltmeters and ammeters has just been published by the *Bristol Co.* The Bulletin, #E1111, describes the features of the instruments, with special emphasis on the newly-developed moving-iron measuring mechanism. Complete information is given on ranges, uses, and specifications of the various models for permanent installation and portable use.

Mining Engineering **July**
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Trends

A REPORT OF CURRENT ACTIVITY IN THE INDUSTRY

THIRTY days . . . hath . . . June and the month found Congress at work on the extension of the National Production Act, scheduled to expire on the thirtieth day. The President appealed to the people for more power to control the economy, but Congress was for extension of the act without either strengthening or weakening it. A move in the House Banking Committee to cut subsidy authority from the legislation was turned away. The Government can thus continue buying from high-cost producers who must sell at above-ceiling prices. The same authority was used to pay extra winter transportation costs for iron ore during World War II.

In the House, the $5 billion tax bill received Ways and Means Committee approval. Some of the ways and means will include: A 12½ pct increase in personal income taxes; a 5 percentage point increase in corporate taxes, retroactive to January; an increase in the amount (87 up to 90 pct) of income taxes that can be taken from an individual; and a 3.1 pct increase in the capital gains tax. Proposals for reduction in depletion allowances for gas, oil, nonmetallics and sulphur were rejected, and the Committee approved an increase in the allowance for coal from 5 to 10 pct. Capital gains treatment was also extended to coal royalties.

Mineral producers confused by the current set-up in Washington were joined by the House Committee on Interior and Insular Affairs, which was presented with a 5-page single-spaced list of agencies and committees connected with the minerals program. The Solons and assorted witnesses agreed that such division of authority might be hampering the minerals program, and recommended that one agency be given both the power and the money to carry out the minerals program. It was reported that two Harvard men surveyed the current defense agency structure and recommended a few changes to ODM head Charles Wilson. He is said to be considering a merger of DPA and NPA, as well as the creation of an independent production agency. Under the second proposal, NPA and the defense agencies now in Interior and under the ICC would be separated from their old agencies and placed in the Defense Production Administration. Cabinet officers, it is said, would probably oppose any such infringement on their bailiwicks.

- **Price ceilings on manganese ore will be removed** immediately, and ceilings on chrome and other strategic materials will vanish shortly, according to Sam M. Ewing of OPS' metal branch. The GSA will be authorized to sign contracts with domestic producers of any strategic material at higher-than-ceiling prices without OPS approval, Mr. Ewing added.

- **Molybdenum ore came under complete allocation** by the Defense Minerals Administration, beginning on June 30. Delivery, or acceptance of delivery, of molybdenum must now be authorized by the agency, and anyone seeking delivery of over 200 lb of concentrates on a contained molybdenum basis must file an application with DMA before the fifteenth of the preceding month. This move brought all molybdenum products, including ores, under Government control.

- **The copper industry is divided over a new topic** now that the import tax problem has been solved by Congress. The recent 3c per lb increase in the price of Chilean copper imported into the United States has created a double market, inasmuch as copper here is frozen at 24½c per lb. Apparently the Government is not willing to either absorb the price differential or raise the price ceiling on copper. The industry as a whole has been urging a domestic price increase to 27½c, but on May 31 Kennecott's president Charles R. Cox became a dissenter. Mr. Cox stated that copper prices should be re-evaluated only when higher prices abroad divert copper from the American market, and he saw no evidence that copper here was being lost because of the higher Chilean price. In the middle of June, smelter operators, unable to buy at 27½c and sell at 24½c, were discussing their problem with the Office of Price Stabilization, but no conclusions were forthcoming.

- **Solid fuels producers needing critical materials** such as steel and copper to maintain output have been asked by Defense Solid Fuels Administrator Charles W. Connor to exhaust all sources of supply before applying for DSFA assistance. DSFA assistance in securing an NPA material allocation should be requested only after the producer has gone beyond his usual supply sources in efforts to procure needed items. Full information as to the circumstances of the case should be given to DSFA for use in approaching manufacturers, distributors, or Government industries.

- **Sulphur usage by American industry in 1951 has** been restricted to the amount used last year, by NPA Order M-69, issued June 1. Suppliers must file, before the first of the month preceding the calendar quarter in which shipments are to be made, Form NPAF-99, listing their proposed shipments for the quarter. NPA will check and return the form ten days before the quarter begins. Users must make a monthly report, before the 28 of each month, on sulphur usage during that month and the inventory at the month's end. Estimates of usage during the current month, as well as anticipated final inventory, will also be filed with NPA. Sixty short tons or less a month may be shipped without authorization, and users of 20 or less short tons per month are not required to report.

- **A General Services Administration contract to** operate a dolomite and a magnesium plant in the State of Washington has been given to Pacific Northwest Alloys, a subsidiary of Chromium Mining & Smelting of Canada. The plants, built during World War II, are located near Northport and Spokane, respectively. The magnesium plant has a rated capacity of 4 million lb per month.

- **The Philippine mining industry, ruined during the** war, is reassuming rapidly its major role in the Islands' economy, and producing over 81 million pesos worth of minerals each year. Having overcome wartime destruction, the industry is now confronted by government regulations, including exchange taxes, the minimum wage law, higher

corporation taxes, rigid import controls, and other deterrents to foreign and domestic venture capital. The RFC and ECA chips, totaling more than 20 million pesos, are down, but Filipinos dislike the proviso that all the assets of a company, plus the personal securities of directors or stockholders, must be pledged to guarantee loans.

Gold production accounted for the bulk of Philippine mineral production last year (58.69 pct), with ten producers mining 333,991 oz. of the precious metal. The Balatoc Mines and Benguet Consolidated were the leading producers, with the Mindanao Mother Lode, Atok-Big Wedge, Surigao Consolidated, and Lepanto following closely. Marsman Co. will rehabilitate four of its prewar mines this year, and the Masara Mines in Davao are engaging in extensive development work.

Copper, chrome, iron, manganese and lead showed increases in 1950 of 26 pct over the previous year. Lepanto and Mindanao Mother Lode were the leading copper producers, and are of course finding stimulus to greater effort in the current era of shortages and higher prices.

Iron mined in the Islands during 1950 went to Japan, with three producers sending more than half a million tons across the Pacific. The U.S. took all the refractory and metallurgical chrome ore (206,665 tons) produced by Consolidated Mines at Zambales. Sabotage at one mine, and a lack of shipping facilities, are expected to cut down chrome shipments this year. Another critical material, manganese, drew mining investors last year. Three big operators and eight small ones produced nearly 30,000 tons during the year.

- **A slowdown strike at Chuquicamata has cut** monthly production of copper there in half. Only 8000 tons per month are now forthcoming, instead of the usual 16,500 tons. Calm is said to prevail, however, with work proceeding normally, if slowly.

- **Manganese output is still at a low level. Shipments** of manganiferous iron ore and ferruginous manganese ore were down 1400 tons in March as compared to February totals. Imports declined 4 pct, although the first quarter total was higher than in 1950. Shortages of ocean transport and foreign rail facilities are expected to lessen the expected total increase for the year. Of the imports thus far this year, India supplied 41 pct, Gold Coast and Union of South Africa 19 pct each, Brazil 6 pct and Cuba 4 pct.

- **Import duties on lead, zinc ores, chromium, titanium,** copper and numerous other commodities declined on June 6 as a result of the recent International Tariff Conference at Torquay, England. The duty on titanium went from 25 to 20 pct; on lead 2⅛ to 1 1/16c per lb; on copper 15 to 12½ pct; on tungsten carbides 30 to 25 pct.

- **A $7 million alloy producing plant at Graham, W.** Va., and a $1.5 million investment in new facilities at the alloy plant at Niagara Falls will form part of a major expansion program now being carried out by the Vanadium Corp. of America, according to president W. C. Keeley. Full benefits of the program should begin to reflect in 1952 operating results, Mr. Keeley said. The company's sales for the first 4 months of 1951 totaled $10,650,000, or 42 pct above the volume of business for the same period in 1950. Earnings before taxes were up 63 pct over last year's totals.

- **A census of American direct investments abroad,** the first since World War II, is being conducted by the Dept. of Commerce. Information on the size and composition of such investments, foreign earnings of American companies and data on transactions between companies and their subsidiaries are sought. The census is mandatory, and reports must be filed by July 31. Forms are available from the balance of payments division of the Dept. of Commerce in Washington.

- **Mufulira Copper Mines is discussing with ECA** officials the possibility of an $8 million loan to be used for expansion and development of the company's property in Northern Rhodesia. Where the extra copper production would go is the chief concern of the American officials.

- **The Russians are producing at least 111 million** cu ft of gas per hr by underground gasification of coal, according to a report in an Italian technical journal. The calorific value of the gas has been rated up to 465 Btu per cu ft.

- **Iron ore shipments from Steep Rock Iron Mines** Ltd. reached 209,305 at the end of May, 33,000 tons more than the comparable period in 1950. All of the current production is from the Errington open pit, but the company is readying the Errington underground and the Hogarth open pit for production. Inland Steel is also working on a separate area of the range, and a group headed by Pickands Mather is also opening up another separate area at Steep Rock.

- **Construction of the 360-mile railroad from Seven** Islands on the St. Lawrence River to Burnt Creek in the Labrador iron ore fields is in progress. The most difficult part of the construction is the first 100 miles, in which the railroad is to climb 2000 ft to the "height of land," from which point the right of way follows the shores of many lakes into the property. Photo shows a construction scene along the shore of one of these lakes. A base camp has been established at the 100-mile point, to which construction equipment is flown.

Pathway to Labrador iron ore deposits.

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DUCTILE IRON is a cast ferrous product which combines the *process advantages* of cast iron with many of the *product advantages* of cast steel.

No longer in the pilot-plant stage, this new material is now produced and sold on the basis of specifications. Not only are its individual properties exceptional, but no other common engineering material provides such a combination of excellent castability and fluidity, with high strength, toughness, wear resistance, and machinability.

Actually, "ductile iron" denotes not a *single* product, but rather a family of ferrous materials characterized by graphite in the form of spheroids . . . a form controlled, in a broad sense, by small amounts of magnesium. Presence of spheroidal rather than flake graphite gives this new product a ductility that is unique among gray cast irons.

Four important types of ductile iron now being produced commercially are tabulated below.

REPRESENTATIVE MECHANICAL PROPERTIES OF COMMERCIAL HEATS OF DUCTILE IRON

	Grade	Tensile strength, psi	Yield strength, psi	Elongation per cent	BHN	Usual condition
A	90-65-02	95/105000	70/75000	2.5/5.5	225/265	As-cast
B	80-60-03	85/95000	65/70000	5.5/10.0	195/225	As-cast
C	60-45-15	65/75000	50/60000	17.0/23.0	140/180	Annealed
D	80-60-00	85/95000	65/75000	1.0/3.0	230/290	As-cast

A Pearlitic in structure. Provides good mechanical wear resistance.

B Pearlitic-ferritic in structure. Provides strength and toughness combined.

C A fully ferritic structure usually obtained by short anneal of either (A) or (B). Provides optimum machinability and maximum toughness.

D Higher phosphorous content than preceding grades, also higher manganese. Provides high strength and stiffness, but only moderate impact strength.

SOME UNIQUE PROPERTIES OF DUCTILE IRON

1. Its elastic modulus, about 25,000,000 psi, is virtually unaffected by composition or thickness . . .

2. It can provide a chilled, carbidic, abrasion-resistant surface supported by a tough ductile core. No other single material can combine these properties . . . its only counterpart being a tough material coated with a hard welded overlay.

3. As-cast ductile iron of 93,000 psi tensile strength has the same machinability rating as gray iron with a strength of 45,000 psi.

4. Annealed ductile iron can be machined at a rate 2 to 3 times that of good quality gray iron.

5. It can be satisfactorily welded.

APPLICATIONS

Automotive, agricultural implement, railroad and allied industries apply ductile iron, as-cast and heat treated, in components too numerous to detail.

Machinery, machine tools, crankshafts, pumps, compressors, valves and heavy industrial equipment such as rolls and rolling mill housings, utilize its high strength and rigidity.

In scores of engine, furnace and other parts serving at elevated temperatures, it provides oxidation and growth resistance heretofore unavailable in high carbon castings.

Other applications include paper, textile and electrical machinery, marine equipment, and pipe.

AVAILABILITY

Send us details of your prospective uses, so that we may offer a list of sources from some 100 authorized foundries now producing ductile cast iron under patent licenses. Request a list of available publications on ductile iron . . . mail the coupon now.

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An ore search for commercial titanium-bearing ore deposits is in progress by the Crane Co., manufacturers of valves, because they expect this metal to be important in valve manufacturing in the future. The company will eventually be mining and making titanium sponge. At present they are buying titanium tetrachloride from the Stauffer Chemical Co. at Niagara Falls and making titanium by reaction with magnesium.

Production from the Babbitt concentrator of Reserve Mining Co. is scheduled to begin in late 1951 or early 1952. The capacity is to be 300,000 tons of pellets per year made from magnetic taconite concentrates.

Over-all accident frequency rates for the Lake Superior iron mining district decreased 16 pct in 1950 as compared to 1949. Al Kohm, assistant safety supervisor for Pickands Mather, reported the rate at 16.26 for 1950 which is the lowest for the past 9 years. The severity rate was 2.77 an 11 pct improvement over 1949 and the lowest in the last 11 years for which statistics have been compiled.

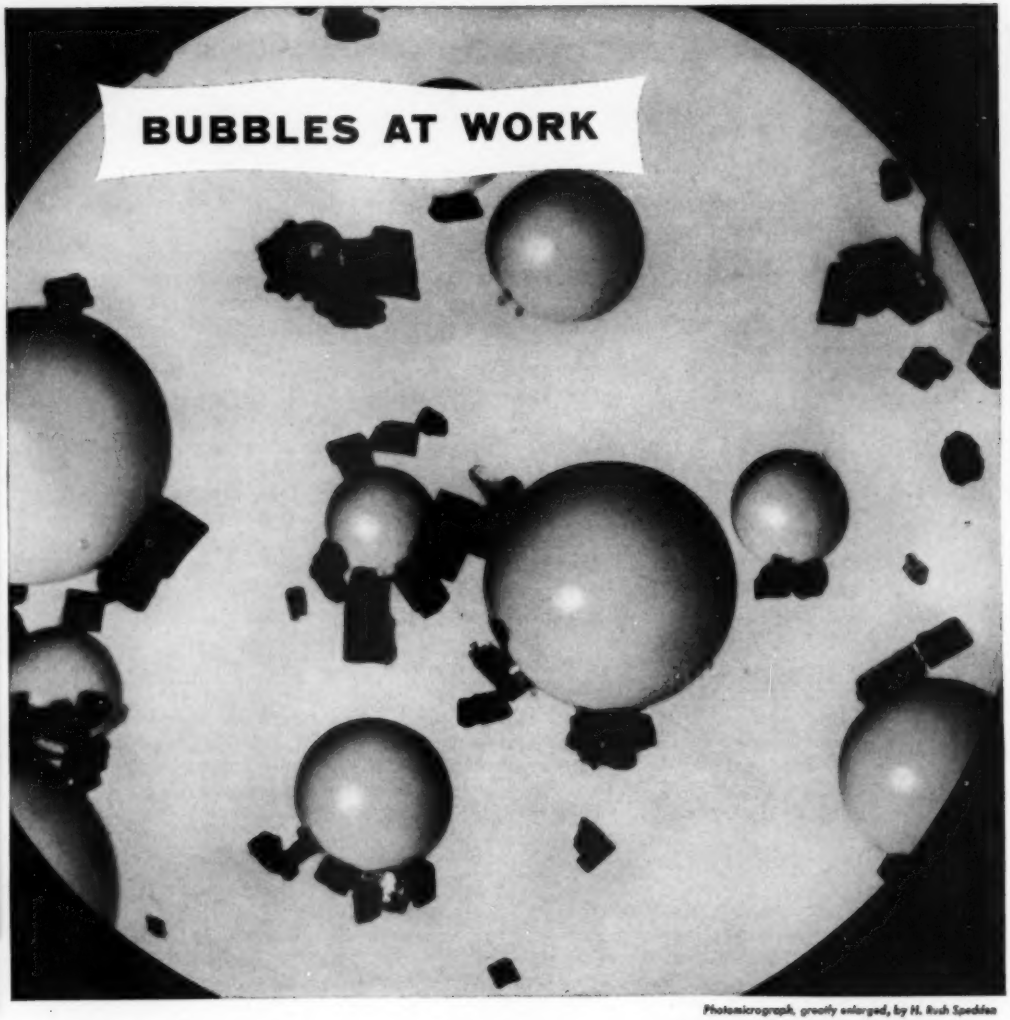
Sulphur industry members believe that the key to unlock production from sources of sulphur other than present commercial brimstone deposits is price. Although this production would be high-cost, the sources could supply vast amounts. The sulphur shortage in 1951 is expected to be greater than in 1950, during which year it amounted to 6½ pct of production. Sulphur users are on voluntary allocation from the producers.

Industry will be able to count on about 19,000 engineering graduates this year according to a report made by the Engineering Manpower Commission of Engineers Joint Council. This is just 50 pct of the total number of graduates, the remainder being expected to go into military service. The estimated annual need of engineers is about 30,000. The report was based on a survey of engineering colleges.

"Coal will preserve a sizable role as a railroad fuel until the success of new technique in application can provide the means and incentive to wage another battle for dominance in this market" according to G. D. Creelman, director of research of the M. A. Hanna Co.

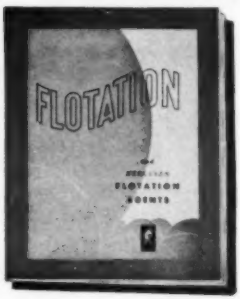
Further cutbacks in the limited supply of nickel available for civilian production probably will come soon, according to Manly Fleischmann, NPA administrator. Nickel is considered the toughest single supply problem because the military demand is enormous and nickel is used universally in industry.

Higher prices for both silver and cobalt are resulting in a marked revival in the famous Cobalt, Ontario, silver mining camp. A score of properties are under exploratory development and some new finds have been made.



Photomicrograph, greatly enlarged, by H. Rush Spedden

To help step-up flotation recoveries at low cost, Hercules has developed a number of frothers and collectors. Yarmor® F Pine Oil has been a standard of quality among pine oil frothers since the early 1920's. RADA (Hercules' Rosin Amine D Acetate) is a siliceous mineral collector that has good solubility and is easy to handle. It is used in the commercial flotation of several nonmetallic ores. These and other Hercules products are described in a 16-page technical booklet, "Flotation and Hercules Flotation Agents." This booklet also contains many formulas useful in the operation and control of modern ore-dressing mills. *Send for your copy.*



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HERCULES Flotation Agents

NM51-1

MINING ENGINEERING

EDITORIAL

A NEW PROCESS BUILDS AN INDUSTRY

Daniel C. Jackling, legendary for his foresight and daring in mining ventures, was the first to attempt commercial recovery of iron from taconite when he formed the Mesabi Iron Co. in 1916 to mine taconite at Babbitt, Minn. The project failed mainly because of the high cost of mining the hard massive beds of magnetic taconite which lie beneath the glacial mantle at the eastern end of the Mesabi. Today, more than a generation later, his dream is about to come true. Minnesota is on the verge of a mining boom unlike anything previously seen in the history of this famous mining state. The ominous course of world events and the development of the Jet-Piercing process for making blastholes have linked to resolve the economic and technological imponderables in the path of taconite development. Three companies representing the nation's greatest steel interests will be in the business of large scale manufacturing of an agglomerated product from taconite concentrate suitable for the blast furnace or open hearth. Thousands will find employment in this new industry and within the decade, from 30 to 40 million tons a year of this iron ore will be supplying industry from a rejuvenated Mesabi.

Because we think that the Jet-Piercing process is the keystone in the span which will support new reserves of iron moving from the crust of the earth to the iron and steel making furnaces, a color photograph of a Jet-Piercing machine has been chosen for our cover this month. The process has been tested rigidly and its acceptance proved by the demand for more of these machines. The technical description of the process and what it is doing are ably told on P. 585 by D. H. Fleming and J. J. Calaman.

Mining of taconite is more akin to quarrying than to the large scale earth moving operations used in Minnesota mines or on the western porphyry coppers. Excavations several miles long with benches of hard rock such as will be necessary for commercial taconite mining impose rigorous drilling conditions. One Jet-Piercing machine will produce from 90 to 150 feet of hole per shift. The experimental machine averaged 112 feet per shift for one week. Because the taconite formation is not of uniform hardness, other methods of drilling will be used. However, it is the Jet-Piercing process which has given the green light to this undertaking.

The availability of foreign ores will not deter the taconite program. The national defense requirement of 120 million tons of ingot steel capacity by the end of 1952 superimposed on the diminishing reserves of open-pit, direct-shipping ore presage a demand which will consume domestic, foreign and taconite production alike. Nothing can substitute for large shipments of iron ore which are within the continental limits of the United States and thus safe from wartime shipping menaces, expropriation, or diversion by other nationals for their own use. Conservation of soft open-pit ores is another consideration for they will be needed for emergency demand and for blending with the manufactured taconite products until melting techniques are able to cope with 100 pct agglomerated blast furnace charges.

MINING ENGINEERING takes pride in saluting those companies and individuals who have accepted the challenge to engineering ingenuity and built a new industry which will insure the prosperity and safety of the nation.

Mining Needs Research

Long ignored, research has been stimulated by high mining costs, low-grade ores, and the scarcity of strategic metals.

by E. P. PFLEIDER

THE history of fundamental research in mining is not one of which the profession can be particularly proud. It has been one of the slowest industries in applying the fundamental sciences to the solution of many of its more difficult problems. True, many of the processes are not adaptable to laboratory techniques, and much of the work must, of necessity, be done in the field. It is for this reason that the mining executive seldom has been conscious of the value of research on a laboratory scale on problems pertaining strictly to mining. Most of them, however, fostered much testing in the allied fields of ore dressing and metallurgy.

Has this stand been justifiable? Many think not. There has been a definite swing toward more organized research in mining within the last decade. As in other fields, labor problems and mounting costs in the face of competition have forced the issue.

History of Mining Research

In retrospect, it seems that the views on research and changes in mining methods and equipment have passed through four phases, each generally related to a period.

Prior to World War I mine foremen were practical men who normally modified proven methods to serve their immediate needs. Little systematized testing was done, either underground or on test blocks.

The classical work of Fayol[1] with models to determine the characteristics of arching and caving over mine openings, as well as the subsidence effects of the surface, was conducted in 1885 and is still widely quoted in texts on this phase of mining. His domal theory was based upon experiments with artificial beds of earth, sand, and plaster, in small boxes.

Engineers assumed, between World War I and 1929, an ever increasing role in management, resulting in more innovations of methods employed in other mining camps, and more systematized testing of performances in the mine.

The Bureau of Mines[2] initiated a program of testing and education, particularly in the fields of mine fires and explosions, blasting techniques and safety. The testing station at Pittsburgh was established. Much original research and test work was undertaken in ventilation and air conditioning by McElroy and Richardson. This work of the Bureau is an outstanding example of the value of a definite long range program.

The mining schools did little or nothing in the field of research, applied or fundamental. Many of the schools were in their infancy and rightfully directing their attentions to the development of a good curricula or the building of a student body. Weeks[3] at California did outstanding work in ventilation that, together with the findings of Richardson and McElroy, did much to improve working conditions underground.

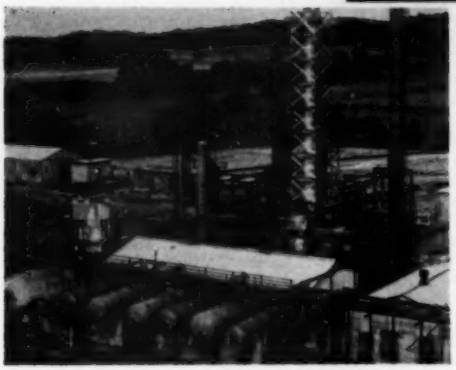
The third period, from 1929 to World War II, included the depression years, in which every attempt was made to cut costs. Operating personnel were forced to try new methods, usually on a small scale. Engineering staffs did more test work. The equipment companies developed improved labor-saving equipment.

Several companies started specific research projects based on laboratory tests. Climax Molybdenum, always outstanding in this respect, built a block caving test model[4] to simulate conditions in the mine. It helped to determine block size, drawpoint spacing, and predicted boundary lines and angle of draw. Anaconda set up its research department,[5] to develop and test new ideas and equipment, and render comprehensive reports with recommendations. The department assisted in developing the new slot-slice system of mining, and initiated the testing and use of the burnt-cut round, smaller bits (resulting in faster drilling speed with lighter machines), and one-pass bits. One of its principal successes has been in the standardizing of methods and equipment throughout the mines on Butte Hill. Experience definitely proved that the engineer, divorced of all problems of personnel, production tonnage, and costs, is far better equipped to develop and test new ideas. He draws not only on his own practical experience, but also on the ideas and suggestions of the operating staff.

Meanwhile, the Bureau of Mines continued its testing and educational programs, but still confined them principally to safety, ventilation, and coal mining. The results were presented in the various *Bulletins* and *Reports of Investigation*. Many information circulars were published, describing mining methods and costs at mining camps throughout the country. This information, together with that pre-

MR. PFLEIDER, an AIME member, is head of the department of mining at the School of Mines & Metallurgy, University of Minnesota.

Useful research is in progress at (right) the famed Battelle Memorial Institute in Columbus, Ohio, and (below) the Bureau of Mines coal hydrogenation plant near Louisiana, Mo.



sented in AIME technical publications, did much to encourage changes and trials of new systems. But little fundamental research was undertaken by the Bureau in mining fields other than fuels, health and safety, and ventilation.

During this period of marked progress several mining schools initiated some basic research work in mining problems. Columbia's P. B. Bucky employed small scale models in a large centrifuge to induce high magnitudes of forces and hence simulate pressures found at depth.[6] By using stroboscopic lighting, plastic models, and the principles of photoelasticity he was able to correlate strain-stress relationships around open workings of various shapes. The results were helpful in understanding the problems encountered in block caving and deep mining. In the latter case, the difficulty of maintaining openings and the danger of rock bursts were serious threats to continued operation. J. D. Forrester at the Missouri School of Mines has undertaken several research projects in explosives, scraper design and performance,[7] and the carbonization of coal in place. The experiments on the carbonization of coal are fostered by coal companies, with the object of determining the feasibility of utilizing thin worthless seams of coal in place through conversion to hydrocarbon gases and CO.

The years since 1946 have witnessed a great resurgence of mining research. Advances in the sciences during the war years highlighted the importance of research in all fields. Rising labor costs, the increasing scarcity of high-grade ores, and mining at greater depths, have forced improved and startling changes of practices.

The proper spheres of influence for research in mining would seem to be as follows: In industry—applied research and field testing; In the Government—fundamental research and sponsorship of field testing; In universities—fundamental research and certain aspects of applied research.

Industry has led the way in *applied* research in the mining field. The tungsten-carbide bits, throwaway bits, and alloy drill steel are a few of many developments that are revolutionizing the costly drilling of rock. Research in jet piercing pointed the way to a new technique of making blastholes. Many large companies are establishing research departments in mining. The use of block caving on the Michigan ranges and the dragline-belt conveyor combination on the Minnesota ranges represent the fruits of practical research.

The mining industry has done little in *basic* research as yet. This field, then, is the responsibility of the Government and the universities.

Government

The Bureau of Mines has been shifting the emphasis from its wartime program of exploration and development of new orebodies to its rightful role of fundamental work. This is finding expression in the following fields:

(a) Determination of the physical properties of all principal rocks. Such aspects as strength in shear, tension, and compression are vital in predicting and overcoming troubles when mining at depth.
(b) Study of diamond drilling in all of its aspects.
(c) Development of equipment to measure strain in rock.
(d) Photoelastic studies of stress-strain relationships for various size and shape openings. Much of this work is done by the physicists attached to the Bureau. It has direct application in the development of a cheap mining method for the oil shales.
(e) Development and application of roof bolting.
(f) Drill rounds and micro-delay blasting.
(g) Use of shaped charges.
(h) Development of new techniques and equipment for the mining of oil shales.

Universities

The mining schools are likewise becoming research conscious. Some of the work is in the field of fundamental science, other in the realm of applied or industrial research. Needless to say, the programs are modest in scope when compared to the extensive outlays undertaken in the chemical, electrical, mechanical, civil, and aeronautical engineering fields. An inquiry sent out to some of the institutions actively sponsoring graduate work in mining fields brought prompt replies to questions relating to re-

Timbering and timber failure have attracted the attention of many researchers. This scene is in a Pennsylvania iron mine.

search projects. These replies are summarized in Table I.

In general, the current research work falls under one of the following ten classifications:

(a) Barodynamics—the study of earth pressures and their effects.
(b) Rock failure; rock bursts; subsidence.
(c) Design of ground support; optimum size and shape of underground openings.
(d) Flow of fragmented materials; rock fragmentation through induced stresses.
(e) "Making hole" in rock.
(f) Fundamentals of explosives and blasting.
(g) Ventilation.
(h) Design and evaluation of mining equipment.
(i) Time studies.
(j) Radio communication underground.

It is immediately evident that the interrelated subjects of barodynamics, rock failure, and design of ground support represent the dominant field of research activity in the colleges. This is altogether fitting, because the development of new mining methods and the ability to mine low grade ores at depths economically will depend on a clear understanding of rock characteristics and the earth's stresses. Clearly, the fundamental principles developed must be applied with the knowledge of field experience to fit a specific complex problem. This tempering, however, does not detract in any way from the value of the basic data. The fields of explosives and ventilation and the "making of hole" in rock are other fertile areas for work. These phases all affect ultimate costs either directly or indirectly.

Several good new research problems were suggested. The development of time studies and production control methods become of increasing importance as mines are more highly mechanized. They provide good subjects for students majoring in mine plant or mine mechanization. Industrial hygiene and dust control in the mineral industry present important and specialized problems in need of study and research. Industrial and public relations problems have been given little study at the college level. They should be challenging to students majoring in mining and minoring in business administration. As an example, a study of the public's reaction to mining, or of its knowledge of the importance of natural resources, should be a worthwhile contribution.

Several schools, located in the heart of mining areas, are in good positions to undertake both basic research and certain aspects of applied research. It would seem proper that these schools give emphasis to the applied phases. Certainly the opportunity of working with mining companies in conducting specialized studies of mining techniques and equipment performance is of distinct value, especially from the standpoint of developing a research-conscious graduate student. Those schools remotely situated from mining areas must focus attention on the more fundamental aspects.

As pointed out by Dr. Forrester in a recent article,[6] cooperative research studies with industry are recommended. A few of the operators and manufacturers have financed such projects through fellowships. This type of program should be expanded by educating the mining executive to the obligations and advantages of encouraging scientific research of mining problems at the graduate level. Many of the companies are willing to assist educational institutions with gifts of equipment or material. This is especially true where the end result might prove of direct benefit.

The prevailing attitude toward college research in mining is well expressed by statements received from various mining engineering department heads. These are presented in Table I. In essence, they feel it to be the responsibility of the schools to promote research, particularly in the application of basic principles.

Most educators agree that this work must be done at the graduate level. Under present conditions most students majoring in mining wish to get into production immediately upon graduation. Something then must be done to entice the student with a talent for research into studying mining. Experience indicates that the establishment of an interesting research program often will do this automatically. Geological engineers, desirous of obtaining a master's degree, make an excellent student-type for mining research.

In closing, a quotation from the paper "A Philosophy for Conservation" by Edward Steidle[7] is appropriate: "To replenish temporarily the pool of basic principles is the function of theoretical research. It is in this field that the role of the school of mineral industries should be paramount. The school must help to guide industry while preserving at the same time its own independence and judgment. It should blaze the trail that will open new frontiers in the mineral arts and sciences without being fettered too heavily by practical ideas that may be worthwhile today but outdated and dead tomorrow."

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Table I. RESEARCH PROBLEMS IN MINING

School	Current and Past Research	Planned Research and Suggested Problems	Comments
A	1. Laws governing flow of fragmented materials 2. Barodynamic solutions of geologic structural problems 3. Stress distributions around mine openings 4. Rock bursts 5. Determination of underground opening dimensions	1. Laws governing gas flow and ventilation of underground openings 2. Stress distribution in geologic structures 3. The physical properties of geologic materials 4. The rock burst problem 5. Vibration studies in rock structures 6. Blasting effects in geologic structures 7. Geophysical and chemical prospecting	"Research in mining at colleges will, it is believed, become of increasing importance as soon as its value is more generally appreciated. We here believe in it strongly and feel that the interest of the staff and its engagement in research are important prerequisites. It is believed that if courses are designed to call the students' attention to the problems therein, not as yet solved, interest in research will result."
B	1. Compressive strength of various types of square sets 2. Direction and magnitude of forces acting on square set timber	1. Use of mine models in planning coal mining methods	"College research should play a definite part in the education of future mining engineers and in the solution of mining problems."
C	1. Explosive studies (3 proj.) 2. Underground carbonization of coal and oil (2 proj.) 3. Stabilization of underground openings (3 proj.) 4. Design of mining equipment; drilling and loading device (2 proj.)	Continuation of present research	"I believe mining schools have a major responsibility to encourage and sponsor research in the mining field, otherwise we do not fully meet the obligations of our responsibilities as teachers. Further, the profession loses its standing as a distinct engineering field."
D	1. Fundamentals of rock failure a. Depth of cover for protection against blasts of high order b. Design of mines and supports for underground openings subjected to bomb bursts c. Control and prevention of rock bursts d. Mechanics of vein formation e. Control of local and regional subsidence in underground and open-pit mines f. Improvement of existing mining methods through applications of fundamental principles of rock failure		Large scale field studies are in progress for Protective Const. Dept., U. S. Army Engineers and Air Force. These deal with fundamentals of extreme importance to mining engineers.
E	1. Study of underground haulage using battery power 2. Time studies of mining, loading, and haulage cycles	1. Breaking of coal using air and CO_2 2. Production control methods using models 3. Equipment performance evaluation	"Of definite value if backed by industry and supported by school."
F	1. Diamond drilling a. Crystallographic orientation of the diamond b. Cutting action of bit c. Relation of size of cuttings to rate of penetration and diamond wear 2. Radio transmission underground	1. Mine fills 2. Drilling of rock 3. Mine and mill hygiene 4. Industrial relations 5. Effect of bonus systems 6. Types of bonus systems 7. Public relations	
G	1. Evaluation of drill jumbos in operating mines 2. Comparison of timbering methods 3. Study of stemming 4. Leaching of filling material in old stopes 5. Investigation of detonators 6. Mechanical loading		Arrangements made with the mining research department of large mining company permitting graduate students to work in cooperation with research dept. on a problem mutually satisfactory to the mining dept. of the school.
H	1. Failure of mine openings by use of models loaded in triaxial compression	1. Improvement in the quality of mine atmosphere	
I	1. Useful energy obtained from commercial explosives under controlled conditions 2. Fundamentals involved in blasting process 3. Stresses around mine openings 4. Fundamentals of mine ventilation	1. Principles of comminution 2. Fundamentals of coal dust explosives 3. Fuel utilization 4. Mine safety	". . . we believe something can be done about the matter of basic and applied research in mining. In our researches we are attempting to get to the fundamentals of certain problems . . . . in the end that they may be of importance in mining operations."

CONTRACT IN PERU

an engineer's wife is more concerned with stores than stopes, and she answers the question—can you get rich overseas?

by MRS. H. T. HEARD

THE prospect of overseas employment is usually intriguing to young mining engineers just beginning their careers. An aura of travel-folder glamour accompanies thoughts of far-off places, but there is also the hope that living expenses will be lower abroad, thus stretching salaries.

Such plans invariably come to life in the form of the myriad details of daily living in a foreign country. Unforeseen problems arise, unanticipated pleasures are encountered—there are, in short, quite a few "angles" to the bald statement: "Tom Heard has just signed a three-year contract with Cerro de Pasco in Peru."

Cerro de Pasco pays the fare of the man and his family from the U.S. to the site of employment. They pay for chest X-rays, physical examinations, vaccinations, and inoculations, passports, visas, etc. They also pay transportation charges on a specified amount of household goods shipped to Peru, and provide married employees with a one- or two-bedroom house at the amazing rental of $10 or $15 a month, including electricity, water, and heating fuel, as well as power for the electric heaters. For the benefit of single men, the company operates hotels providing room and board at a nominal fee.

My husband and I were told that quarters for married couples had been furnished by the company with tables, chairs, beds, stoves, etc., but that we were required to supply our own linens, bedding, curtains, kitchen utensils, dishes, and other household goods. We learned that washing machines, refrigerators and electrical appliances of all kinds are extremely expensive in Lima, and suggest that anyone moving to Peru ship these items along with other household equipment. Although a wide variety of curtain and drapery materials are available in Lima, they are not cheap. Dishes, both imported china and Peruvian pottery, are priced well above similar products in the States, and we regretted not having shipped our dishes because of supposed packing difficulties. There is little breakage of china and glassware that is well-packed.

My husband's employment contract called for 15 days' vacation semi-annually, at full pay. As most of the company's mining properties are at an altitude of over 12,000 feet, the majority of the employ-

ees spend such vacations as near sea level as possible. Cerro de Pasco maintains a sort of family-style hotel, for families who wish to stay in Lima.

During each vacation we tried to cover a different portion of Peru. We visited the Inca ruins near Cuzco and were amazed at the industry and building ability of these primitive people, we visited the famous Sunday Fair at Huancayo, saw modern Arequipa and the much-advertised volcano El Misti, and we traveled north along the coast to Chimbote and Trujillo, visiting fisheries and sugar plantations, including the well-known Paramonga operated by W. R. Grace & Company. We found that the northern desert country had much in common with my native Arizona, but also had many scenic wonders different from anything we had seen before.

The Andes Mountains in which we lived were rugged peaks, some covered with snow, others just bare rock, with little vegetation. We were sent to Morococha, at an elevation of 14,500 feet (above timber line) so were surprised to find well-kept lawns, flowers growing in window boxes, and a few hardy varieties in the yards. Most of the houses were built of adobe, with a stucco finish, had electric water heaters and modern plumbing, leather-upholstered light oak furniture, and fireplaces in the living rooms. Each house seemed to have at least one Indian girl to do housekeeping chores, and as wages for domestic servants averaged a little less than $10 a month, some of the women had extra laundresses and cooks, too.

Most of the women in these camps dress much as they would at home, with cotton house dresses and slacks during the day, and something a little dressier for the bridge clubs and other social affairs. The majority wear low-heeled shoes around home, and an extra pair is nice to have as there is little pavement in the "hill" country, and shoes wear out faster on dirt roads. Quite often the big dances of the year (New Year's Eve, Christmas, etc.) are formal affairs, and most of the women have one or two evening gowns. A few of the men have dress suits or tuxedos, but most of them seem to find that a business suit is adequate for most parties. Someone advised my husband to bring whipcord riding breeches for underground and field work, but the consensus here seems to be that they are a needless expense, and most of the men wear washable cotton gabardine or twill slacks and shirts to work, under cotton coveralls. (Coveralls are necessary because the mine here is fairly wet and acid water dripping from overhead plays havoc with work shirts.)

Cooking at 14,500 feet is problematical. Cake recipes that worked well at sea level produce soggy, inedible results in the Andes. Although American companies informed me that they had not conducted tests at more than 10,000 feet, I found that their adjustment tables and altitude cook books produced good results in Morcocha. Gold Medal Flour, General Foods Corp., Pet Milk Co., and Colorado A&M College put out excellent cook booklets for a variety of dishes. Modern electric ranges are in all the houses at Morococha, but cooking at high altitudes is of course a slow process. However, as at home, pressure cookers are time-savers.

Company owned and operated mercantile stores are at sites convenient to each camp. Meats, vegetables (both fresh and canned), and other staple food products can be bought for cash or charged on a monthly basis. Although some clothing and household equipment, both local and imported, is sold in these stores, the company itself advises families to come as well-equipped as possible, since prices on imported goods are quite high. Men should have an ample supply of work clothing because, although hard hats are available locally, it is often difficult to find correct sizes in boots, socks, underwear, shirts and trousers.

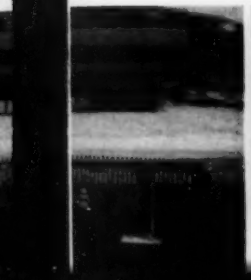
Most of the camps have clubs complete with bar, movie theater, library, pool or billiard tables, some have bowling alleys and tennis courts, and some have 9-hole golf courses. Sports fans should bring their own equipment. We found many places where trout were abundant, and ducks, game birds similar to our partridge, small Peruvian deer, and an odd squirrel-like animal known as a biscacha could be hunted.

Each camp has a well-equipped hospital with one or more doctors in attendance. Children are well provided for, as it is Cerro de Pasco's policy to have a school in each of its camps where there are six or more English-speaking children. Many families take advantage of these schools, but several send their children to school in Lima, and say that such schools compare favorably with those in the States.

A knowledge of Spanish is essential for life in Peru. Engineers must be able to give orders to their workers in Spanish, and the women must learn the language in order to shop, or give instructions to their domestic help. A good dictionary is essential. Many textbooks prove helpful, although of course there are several ways of learning the language, including correspondence courses and sets of records. Listening to Spanish radio broadcasts is good practice, too. A fairly powerful shortwave set is the type of radio needed.

Life in a foreign country is different and interesting—but wealth doesn't come with the first contract. Starting salaries are about on a par with those paid to geologists, engineers, etc. by the mining companies in the States, and although some items, such as rentals on company houses, are fairly reasonable, others cost more than double the U. S. price. Living costs as a whole are about equal to those in most mining towns in the United States.

Large photo shows Morococha, 100 miles northeast of Lima, where 24 contract employees and their families live. Employees live a few miles away at Tuctu. At bottom, (l to r) Tuctu from a distance, showing wall surrounding it and the Trans-Andean highway; Tuctu hotel for unmarried men; playground for children at Morococha; llamas on shore of Lake Pomacocha; washday for native women.



ESTABLISHING THE VALUE OF MINERAL PROPERTIES

Potential, not past earnings form the basis of valuation. Markets, taxes, transportation and numerous other factors are also of prime importance.

by BLEECKER L. WHEELER

THE real value of any mineral property, developed or undeveloped, depends on future earnings and the period of future life, that is, on the present worth of the prospective net earnings from the property. This is an old concept, but it needs reiteration because there is an unfortunate tendency, frequently in the valuation of coal properties, to first carefully estimate the tonnage of coal in the ground and then to apply some selected unit value, say 3c, or 5c or 10c per ton, in order to establish an alleged value for the coal deposit. Any such procedure is entirely fallacious.

Another important consideration is the fact that *past* earnings are definitely not a direct factor, in themselves, but only insofar as they constitute a measure or yardstick to indicate the probable future earnings. Estimated earnings in the years ahead, rather than actual earnings in the past, are what a potential investor is interested in, and are those which serve to establish the value of the property.

Thus, the commercial, or fair value is that price which a potential purchaser would be justified in paying in order to obtain a reasonable net profit on his total investment under anticipated conditions of operation and marketing, together with such a further amount as will provide for the recovery (that is, amortization) of said total investment during a suitable period of years.

Those economic factors which should be taken into consideration in making a mineral property valuation are numerous and varied and include such as the following:

1. The existing and potential markets
2. Freight rates on the product, as these may tend to restrict the possible market territory
3. Conditions which may affect the continuance or expansion of present demand for the product
4. The extent of past and probable future competition
5. Availability of a suitable plant site, if the mineral deposit requires treatment or processing, and of a sufficient area for waste disposal, when required
6. The probable total amount of investment necessary for mine development and for plant construction, when the property is undeveloped.
7. The condition of the physical assets apply when the property is already developed.
8. The amount of working capital required in carrying on operations
9. Special conditions which may affect production costs, such as labor rates, availability of sufficient labor, availability and cost of electric power, and water
10. Access transportation to the property and the probable cost of a road or railroad, if necessary.
11. The estimated salvage realizable from existing physical assets, if the property is developed and operating, since such salvage represents a "floor" or minimum value for the property, under any conditions.
12. The anticipated rate of Federal income taxes on future net profits, since it is only the profit after such taxes that the investor finally realizes.
13. Probably the most important of all, the degree of risk involved in the venture, that is in the extraction of the particular mineral and the sale of the product, in order to settle on the appropriate risk rate for the capitalization of the anticipated net earnings.

The factors of available markets and continuance of demand for the product, together with the related problem of competition, are of prime importance and these must be carefully explored to ascertain if there is a continuing demand for the mineral product and also whether competition poses a serious threat. Certainly, the value of any such property must be largely dependent on the continued ability to sell the product profitably. Also, either the relative assurance or, on the other hand, the evident uncertainty of future market demand, bears directly on the proper risk rate to be adopted for capitalizing the estimated profits.

Of course there are certain mined products which do not come within this category of marketing in-

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quiry, such as some of the metals. Certainly it is needless to look into the market demand for gold or silver, or probably copper. The factor of market demand is, however, important in the case of other minerals, such as Fullers earth or rock asphalt.

The factor of competition is closely related but often overlooked. If a rock asphalt property has been producing about half of the total tonnage of sales within its territory (which is apt to be definitely restricted by freight rates), its contemplated ability to expand to provide 75 pct of the total would materially increase its value if such expansion could be accomplished. But this is just what should be carefully looked into, to determine competitive conditions. What may the competing rock asphalt properties do about this? Can they afford to cut their prices? Is the property a low cost producer, capable of meeting price cuts? Or does it have a somewhat higher grade of rock asphalt, so that it can reasonably expect to capture an additional 25 pct of the available market? There are many ramifications of this element of competition.

The factor of freight rates is relatively simple, but should not be overlooked. On low priced products, such as gravel or trap-rock, the freight rate will serve to establish a fairly definite boundary line on the map, roughly the circumference of a circle, beyond which the product cannot be transported and sold at a profit.

The investigation should take into account the topographic conditions on the property, so as to determine whether an ample area is available for mill site or plant site, or for waste disposal, if such is required. In numerous sections of this country, the terrain is such that some considerable cost may have to be incurred for excavation and grading, to prepare a plant site prior to the start of construction.

When the property to be valued is wholly undeveloped, it is important to have complete estimates of the investment that must be incurred in order to fully develop the mineral deposit (it may be by shaft and drifts, for an underground operation, or by a quarry for other types of deposit), together with such accessories as roads or trails, or even a railroad connection; in addition, some form of process plant may be called for, if no more than crushers and screens. What is essential, then, at this point, is knowledge of what total capital investment must be made to put the property on a sound productive basis, where the anticipated profits may be regularly realized thereafter.

A comparable condition may exist in the case of an already developed property, where parts of the plant are found in poor condition or obsolete, so that early replacement expense will be incurred. Where this is the case, the amount to be so expended must be estimated and allowed for.

The element of working capital is in a similar category to that of plant investment costs. It must be determined what amount of money will have to be tied up in working capital requirements, such as payrolls, inventories, accounts receivable, etc. Whatever amount may be necessary, it is entitled to earn a profit, just as much so as is the investment in mine and plant.

It should be ascertained if there are special conditions affecting the availability of labor, and whether or not water and electric power are readily obtainable. Mineral deposits seem to have a habit of selecting distant and rather isolated locations for their occurrence and it may be found necessary to build living accommodations and to offer some kind of premium in order to obtain suitably skilled labor. Similarly, pipe lines or power lines may have to be constructed in order to bring in utility services.

Since net profits, available for dividends, after payment of all taxes, are the objective of the investor, the probable future Federal income tax rate must be estimated and allowed for. If any mining engineer can perform that feat, under present day conditions, he certainly must be good, and it would seem that he ought to change his profession and become a Government economist. Nevertheless, it is necessary to make some kind of an estimate as to an average future tax rate in order to determine probable annual profits after taxes.

The selection of a rate for capitalizing annual earnings is largely dependent on judgment and experience in an evaluation of the risk factors pertaining to the particular mineral property being valued. Whether such rate is to be 7 or 15 or 20 pct must be determined after fully weighing the elements of risk involved in the entire project. Obviously, a new and undeveloped mineral property involves much more risk, and thus calls for a higher capitalization rate, than a property already established and operating.

The period of years during which to capitalize may be more or less elastic if the mineral reserves are more than ample. Generally speaking, a 25 or 30-year period is usually the maximum. Beyond that period, capitalized profits add comparatively little to present value.

The use of the Hoskold formula, utilizing two interest rates, is well worth considering, as it makes for simplicity of computation. The higher the risk rate that is selected for capitalization, the more desirable it is to use Hoskold because of the increased "spread" between such rate and the present low interest rates for a sinking fund to amortize the computed investment.

When a value has been thus determined, there are two additions to the figure that it is well to take into account, namely, the present worth of any estimated salvage and of future working capital. Since the computed value is fully amortized in the Hoskold formula, any realizable salvage and any ultimate recovery of the working capital are both elements that properly may be added, after being reduced to their present worth. Of course, where the estimated life is as long as 25 or 30 years, the salvage would doubtless be low and its present worth might be quite inconsequential.

The importance of not overlooking any expenditures or investments that may have to be made in order to operate the property—mine development, mine plant, possible housing, transportation facilities, pipe lines or power lines and working capital—cannot be overemphasized. It is the total over-all investment on which the profit must be made. If properly capitalized earnings indicate that such total is, say, $500,000, whereas $300,000 must be expended for plant and equipment and put into working capital, then the mineral property itself can have a fair value, or commercial value, of only $200,000. Stated otherwise, after the investor pays $200,000 for the bare property, he must still invest a further $300,000, and the estimated profits must yield a suitable return on the total of $500,000, together with its amortization.

TAXES AND A WAR FOR FREEDOM

A leading executive finds this a bad time to "cry" about taxes. Needed reforms must cede to emergency demands.

by LOUIS WARE

TAXES, one of the certain things in life, are on the move upward. Huge defense expenditures seem to be here for an indefinite stay and, coming on top of the highest budget yet attained in peace time, there must be a tax program that will be productive of the greatest possible revenue. Inflation has already reached the danger point and it is generally realized that taxes must approach a pay-as-you-go basis as closely as possible if the economic side of the military expansion and warfare is to be successful. High taxes hurt, but they are a necessary part of war. Businesses and individuals must give up a greater percentage of their dollar profits, just as manpower and other resources are sacrificed for the common cause.

It is easy for the business man to cry for more liberal tax treatment or for special tax concessions to meet his particular needs. However, in considering the present tax situation, it must first be realized that the government needs to raise the maximum possible revenue during the immediate years ahead. The other requirement is that the tax plan be so arranged that it does not destroy the incentives necessary under a system of free enterprise. Any tax detracts to some extent from the will to do and the urge to produce and earn. During World War II tax rates were fixed so high that incentives for further production were practically destroyed. When the tax rate exceeds 50 pct, where the government gets more of each dollar earned than the earner does, that danger is real. It is a question as to where the maximum tax rate can be fixed and still keep incentive alive and productive. For war needs, there must be expanded production from the farms, mines, and factories. So, there are two sides to this tax question—the need to raise the greatest possible revenue and at the same time, the need to encourage plant expansion and maximum production. Also the tax plan must be as nearly equitable to all taxpayers as possible and must recognize needs for special treatment to meet situations peculiar to different industries.

To meet all these requirements, the tax formulae must necessarily be complicated and can never be perfect. If it were possible to start anew and set up the ideal and simplest tax plan, a better scheme than we now have could undoubtedly be evolved. But Americans will just have to live with the present tax machinery.

In general, the tax measure providing for increased surtax and an excess profits tax which the President signed on Jan. 3 is an improvement over the World War II tax law. The rates are not as high as were expected and there are sensible relief provisions and concessions to special situations. There is of course no certainty as to what raises and changes the future will bring. Taxes may go on to levels that will kill all incentive and then investment of all private funds will stop. The Government must then supply all new capital needs and production can only be maintained by quota plans, the drive, threats, and punishment by an all-powerful central government. Death of the free business system can come about by taxation as certainly as by other means.

During hearings on the new tax law, there was loud objection to the excess profits provision. Many industrialists and others decried such a plan and recommended instead a high surtax rate to provide the same revenue. Under such a plan, taxes would be at a fixed rate, based on earnings without reference to either invested capital base or previous profit record. Labor unions favored the excess profits tax plan and, probably because it had been in force during the last war and was thus better understood, it was again adopted. Once again there are three taxes: normal tax, surtax and excess profits tax. The legislators took the old tax plan and endeavored to write

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in additions and changes that would correct abuses and answer many of the objections that had been raised.

It must be admitted that there are many corrections and improvements embodied in the new excess profits tax. Foremost is the limitation to 62 pct as the total over-all tax any corporation must pay. With the tax rate of 77 pct on profits above the base, the tax payment could be much higher in a greatly expanded business if it were not for the 62 pct limitation. The allowance for a new corporation that did not enjoy profits during the base period is a definite improvement. Fixing $25,000 income exemption from surtax and excess profits tax attempts to answer the objection of the small business man to that plan. The loss carryover feature permitting losses to be carried back one year and forward five years is an improvement over the previous limit of two years carryback and carryforward.

Special Allowances for Mining

One important allowance to the mining operators is the exemption of the normal profit per unit on increased production, subject, of course, to express limitations. This recognizes the fact that the miner, called upon for abnormally high output in wartime, should not exhaust his ores rapidly without the right to retain a normal unit profit.

The provision that exempts from all taxation government incentive payments made to encourage the production of critical and strategic minerals is a fair arrangement. This also clarifies the matter of loans made for exploration and development purposes in that such loans are definitely not to be treated as income for tax purposes.

The measure also includes excess profits exemption for miners of many strategic minerals, namely: ". . . antimony, chromite, manganese, nickel, platinum (including the platinum group metals), quicksilver, sheet mica, tantalum, tin, tungsten, vanadium, fluorspar, flake graphite, perlite, long-fibre asbestos in the form of amosite, chrysolite or crocidolite, beryl, cobalt, columbite, corundum, diamonds, kyanite (if equivalent in grade to Indian kyanite), molybdenum, monazite, quartz crystals, and uranium, and *any other mineral which the certifying agency has certified to the Secretary as being essential to the defense effort* of the United States and as not having been normally produced in appreciable quantities within the United States."

In addition to the relief allowances specifically directed toward the mining industry, there are the following general provisions allowable to all taxpayers who meet the qualifications: Relief for base period abnormalities, for changes in the base period of products or services, for changes in the base period of capacity for production, for new corporations, for industries depressed in the base period, and amortization of defense facilities which, although not a provision of the Excess Profits Tax law, is a form of relief given to qualifying taxpayers under the Revenue Act of 1950. This provision permits plants to be amortized over a five-year period if certified as being necessary to the defense effort.

The tax plan is one of setting high rates to the point where incentive is admittedly deterred and then fixing concessions which will, partially at least, revive the urge to expand and produce for war.

The mining business has risks that are peculiar and different from those of other industries.

In recognition of this fact, percentage depletion allowances have been in effect for many years and have become an integral part of the thinking of mine operators and investors. Congress, in writing such an allowance into the law, recognized the hazardous and speculative nature of mining and concluded that the industry needed particular consideration. Congress must also have recognized that the miner's wasting asset is in the nature of a capital asset, the tax on the income from which should not carry an effective rate as high as the rate applicable to ordinary manufacturing. Thus depletion allowances serve to provide a tax rate applicable only to one type of taxpayer.

Depletion allowances have enabled the miner to constantly seek and develop new orebodies and have thus, in a sense, maintained the mining industry.

With tax rates approaching the level of confiscation, and especially in times of defense and war production when miners are called upon to deplete ore reserves at exceedingly rapid rates, it is imperative that percentage depletion as it now stands be retained in the law. If Congress is kept properly apprised of the need for and the equity of this allowance, it will remain in the statutes.

When appraising the fairness of the treatment given to the mining industry, it is to be noted that industries other than the extractive industry are not given any concessions which are not also given to the extractive industry. Three direct concessions are allowed the mining industry in addition to all other general excess profits relief provisions and the amortization privilege. All of this, plus depletion allowances, makes it apparent that Congress always has recognized the hazards and the peculiar characteristics inherent in the mining industry.

Reform Will Have to Wait

The current heavy taxation program will at best be discouraging to businessmen and investors. But the incentive to expand and produce must not be destroyed. Taxes are already so high that it is extremely difficult to get new capital for risk ventures. When the corporation must pay 62 pct to the government and then the recipient of dividends must again pay a high personal income tax on the return from the business in which he has invested, and furthermore must then pay a sales, excise or other tax when he spends the money, it can be seen that the over-all tax burden has become so oppressive that it slows the whole business plan.

Any general tax reform, however desirable, will probably have to be abandoned for the emergency period. The elimination of double taxation on corporation earnings is a needed change, but if accomplished, the need for revenue would only give rise to other new taxes. It is not wise to seek relief for corporations and investors in the political atmosphere accompanying a period of national crisis.

Today's taxes are light compared to those that would be required to fight a war for survival. It is also worth remembering that the new levies are light compared to taxes in other countries. But this is no excuse for high government spending and burdensome taxes. The nation is unable to support the aims of extensive social legislation and stand the cost of waging a war at the same time. The need for lowered cost in government was never greater than now and it is frightening to have the President recommend further expansion of social undertakings, however desirable, at the same time he proposes the staggering budget for this year. It is possible for us to lose that for which we are arming by tax strangulation even before it is started.

SELECTING TWO-WAY RADIO COMMUNICATION

LARGE, modern, open-pit operations demand communications systems geared to the magnitude and tempo of the work. Radio communication is a reliable lubricant for the wheels of mining progress, but it poses problems not ordinarily encountered by miners. The joys and problems brought by radio to the Morenci open pit constitute the source of the principles given here.

Before installing a two-way radio system in a mine, it is necessary to formulate some basic plan that will serve as a foundation for the engineers and manufacturer. The first factor to be considered is the selection of frequency. This is generally a function of the manufacturer. The frequencies requested must be integrated with the plan of the system and the topography of the area to be served.

The range of a station depends on the power, frequency, and terrain. With two stations of the same power, the one with the lower frequency would have the greater range; that is, 30 megacycles would have a longer range for the same location and power than frequencies in the 152 to 162 megacycle band.

The usual mine is very well served within the 152 to 162 megacycle frequency band and it would be hard to get any other from the FCC. This band, with the proper placement of the central station, adequately serves an area of from 10 to 12 miles with occasional blind spots due to topography. Essentially, this band will transmit only "sight" distances reliably, but within the area of a normal mine a bouncing effect seems to take place and transmission is usually not impaired.

At Morenci, the central station is mounted on a comparatively high hill at the side of the mine and remotely controlled from the dispatcher's tower. It attains almost perfect reception and transmission from any part of the immediate property whether or not the car or station to which the dispatcher is transmitting is hidden from view by rough terrain. This station transmits on a 154.49 megacycle band with a power of 60 w.

Because of intervening hills, transmission between cars is not always effective, but the message can always be relayed through the central station. This station has an apparent working range of 30 to 40 miles in a southerly direction from Morenci, but toward the north, car-to-station signals are cut off by mountains within a distance of 15 to 20 miles. If a central station is used, and this is the usual practice, the transmitter should be located on the highest point in the vicinity.

Expansion of communication facilities must be provided for at the start. Operators invariably find more uses for radio communication than they first anticipate, and the system should be flexible enough to allow for additions. This applies particularly to transmitter power in the central station. The tendency is to purchase a relatively low-powered central transmitter and to place it at some convenient spot, whereas more foresight might double the range and use of the radio system.

The installation at Morenci consists of a central station, remotely controlled; 2 handietalkie units; 2 locomotive units; 15 mobile units in trucks and cars, and a unit in the radio repair shop.

At first it was thought that about 6 sets and the central station would be adequate. But additions have been made and expansion is continuing.

The locomotive sets are car units, in homemade shockproof cases, mounted in two E. M. D. 1000 hp switching locomotives. Power is supplied by an automobile generator belted to the locomotive motor. This use of mobile units in locomotives required much experimentation, but through it the need for buying special locomotive equipment was avoided. Locomotive radio operation is now almost trouble-free.

The two handie-talkie sets, developing only 1½w, are used at Morenci for emergency communication when some failure occurs in one of the other sets. They have also been found useful for watchmen and flagmen who do not need to maintain constant communication. However, they have definite power and range limitation and can be used effectively only where there is a clear line of sight.

The chief use of the 10-w transmitter and receiver units is in supervisors' trucks. There are two models of this unit; one goes under the seat of the truck and the other attaches to the dashboard. The latter is more convenient, requiring a minimum of under-floor wiring. With the exception of certain blind spots in car-to-car transmission, the 10-w sets are entirely satisfactory, although it was necessary to equip the trucks with heavy-duty generators because of low traveling speeds and the necessity of maintaining a charging rate while the motors are idling. The 10-w sets as installed, use about 5 amp on standby-receiving and about 30 amp while transmitting. As an example of how important height is in this frequency band, two cars a mile apart, separated by several hills or even one hill, may not communicate satisfactorily, while the same two cars can receive and transmit at a distance of 30 miles if the line of sight is not impeded.

The selection of equipment cannot be handled satisfactorily by calling for bids. In most cases where the contract goes to the lowest bidder, the man responsible for awarding the job has no knowledge of radio and no source of expert advice. In any case, as a prospective purchaser will probably use a factory representative for this service, he can select one who can be depended on to provide for contingencies and alterations. The possibility of purchasing obsolete equipment is slight. Any sets sold in accordance with FCC rules will almost automatically incorporate all the latest improvements.

Spare mobile transmitters and receivers are required for most systems. If spares were not available, a station or truck would be tied up until the set could be repaired. Normally, only two or three minutes are required to make an exchange if a spare set is available. Most mobile units are now made up with the transmitter and receiver in the same case.

There are two schools of thought on the important points of maintenance cost and outage time. One school advocates the purchase of the finest set possible for quality and dependability in order to keep maintenance cost at a minimum. The other type of purchase involves a cheaper primary cost but a higher rate of maintenance. In general, it can be shown that the radio with the highest primary cost is usually the most economical, as mine equipment normally operates 24 hours a day and radio outage must be kept to a minimum.

Battery-current consumption may be an important consideration depending on the type of service for which the vehicle is to be used. Equipment that is to be used three shifts would usually necessitate the addition of a heavy-duty generator, but a car used only on day shift that travels normally from 20 to 25 mph would not need one. The repair and maintenance setup would differ according to the availability of factory service or possibly the area in which the mine is located. Unless very few sets are contemplated, a small radio repair shop should be set up and maintained on a full or part time basis. At Morenci, the radio repairman has time for only a few outside jobs. FCC regulations require that the repairing of transmitters be done by a qualified man holding at least a 2nd grade license. Regulations also require periodic testing and monitoring of equipment, which can be done either by the local holder of the repairman's license or on a contract basis through the nearest qualified radio service.

At Morenci, it was expected that six to twelve mobile units would occupy so much time on the air that additional units would not be practical and requisitioning of another frequency allocation from the FCC was considered. But mobile units were added with no appreciable crowding of the wavelength. The only explanation for this phenomenon seems to be that most information going out over the air is heard by all set-users. In other words, all set-users, being continuously tuned in, keep a good general picture of the mine operations without the trouble of making calls.

The two-way radio installation in the Morenci open pit saves an enormous amount of time and truck mileage by facilitating and speeding up practically all operations, especially repair work on heavy equipment. The amount saved in dollars and cents is, of course, hard to evaluate.

The dispatcher's work is lessened because calls that once went through him now go directly from person to person. Anyone not having a radio can be quickly contacted, for someone having a radio is almost certain to meet the desired party soon after a call goes out.

The radio installation has already more than paid for itself and mine personnel wonder how they ever got along without it.

Computing Survey Notes With Traverse Tables

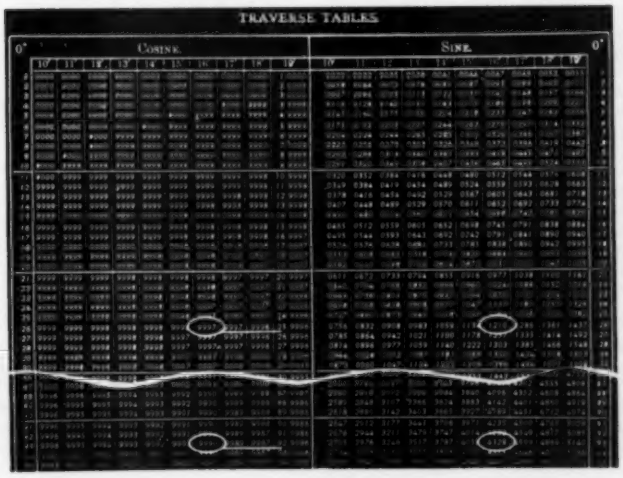
COMPUTING of survey notes can be simplified greatly by the use of Gurden traverse tables to replace the more tedious methods using calculators and natural trigonometric functions, or logarithms. Using Gurden traverse tables to compute the course A-B, for instance, which has a bearing S 89°44 E for a measured distance 9326 ft, it is only necessary to open the Tables to 89°44.

The cosine and sine for 9300 are first read, then for 26,

	Lat	Dep
9300 =	43.28	9299.90
26 =	0.12	26.00
	43.40	9325.90

In Fig. 1 is a section of the Traverse Tables showing arrangement of values for the cosine and sine for distances from 1 to 100. It will be noted that all desired figures are on the same page, and that the only calculations necessary are the additions of the small figures 0.12 and 26.00 to obtain the latitude and departure of the course.

It is also obvious that the number of digits in the units of distance as well as the location of the decimal point causes no difficulty in computing the desired latitudes and departures. In the case of notes for a precision survey, values for angles measured with a 10-second transit can be computed readily by interpolation.



The Gurden Tables are developed to four places of decimals, so that the sines and cosines for a distance of 12 miles can be ascertained to within .5 in. Values given correspond to results obtained by multiplication of six-place natural trigonometric functions with the given units of distance.

The method is valuable in any type of computation where it is necessary to find the product of the sine or cosine function and a given unit of distance or measurement.

It is not the intention of the author to solicit for the Gurden Tables, but to his knowledge they are the only source of computations for each minute of angle. *J. Paul Trueblood, Registered Professional Engineer, State of Idaho.*

Books for Engineers

Nonmetallic Minerals. By Raymond B. Ladoo and W. M. Myers. McGraw-Hill Book Co., New York, 1951. 605 P. $10.—A completely revised second edition, providing comprehensive coverage of nonmetallic minerals essential as raw materials to the chemical and construction, ceramics, fertilizers, abrasives, and other industries. Describes where nonmetallics are found, how they must be treated for commercial use, as well as markets and price ranges. Various beneficiation processes are described. Formulas, physical constants, and worldwide production data are covered.

Mining, Processing, and Uses of Indian Mica. By Chand Mull Rajgarhia. McGraw-Hill Book Co., New York, 1951. 388 P. $8.—Covers all aspects of the Indian mica industry, including geology, prospecting, mining, processing, and marketing. Discusses step-by-step operations in the processing of various grades of mica, with a wealth of statistics, data, charts, and illustrations. Occupational diseases are also covered, as are uses of macinite, short mica, and ground mica for insulators, bonding materials, and electrical appliances.

Bureau of Mines publications—*Reports of Investigations:* 4782, Investigation of a Photoelectric Device for Determination of Low Concentrations of Dust; 4781, Performance of a Pebble Heater Type Steam Superheater; 4783, Chromite Deposits—Sweetwater, Castro, Trinidad, New London, and Hilltop Mines, San Luis Obispo Co., Calif.; 4775, The Role of Oxygen in the Production of Synthetic Liquid Fuels from Coal; 4778, Electrolytic Model Studies as Applied to Water-Flooding a Shoestring Sand; 4767, Concentration of Carbonate and Oxide Manganese Ores from Silver Bow, Jefferson and Park Counties, Mont.; 4759, The Short-Circuiting Contactor as an Electrical Protective Device for Coal Mine Service. *Information Circulars:* 7579, Treatment of Timber; 7595, Safety Consciousness, An Evaluation; 7598, The Use of Visual Aids in the Morenci Branch Safety Program, Phelps Dodge Corp., Morenci, Ariz. Synthetic Liquid Fuels Abstracts, Vol. 4, No. 2, March 1951.

U.S. Atomic Energy Commission Contracting and Purchasing Offices and Types of Commodities Purchased. U.S. Government Printing Office. 15c.—Revised edition of a booklet on how to do business with the Atomic Energy Commission. It answers the questions: what is bought for AEC? Who buys it? Contains lists of commodities purchased by AEC, addresses of purchasing agents and offices, and instructions on how to qualify for bidding. Information is up to date as of March 1951. *Purchase from the Superintendent of Documents, Washington, D. C.*

ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten per cent discount given whenever possible. Order Government publications direct from the agency concerned.

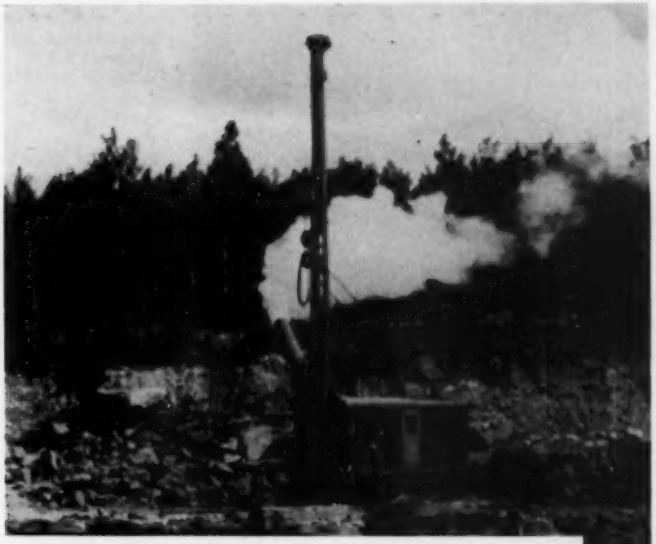
Guide to Geologic Literature. By Richard M. Pearl. McGraw-Hill Book Co., New York, 1951. 239 P. $3.75.—The first reference book of its kind to be published in any language, this volume is a guidebook to the extensive and complex world-literature of geology, its subdivisions and its related fields. Covers all published literature on geology from the earliest times up to the present. Not a bibliography, but rather a well-integrated series of clues on where to find things. Methods of search, library services, Government documents, state, county, and city bulletins, theses, unpublished manuscripts, periodicals, and other sources are suggested.

Journal of Geological Education. At its tenth annual meeting at the University of Illinois, Apr. 14-15, 1950, the Assn. of Geology Teachers voted to proceed with publication of the long-talked-of *Journal of Geological Education.* Present plans are for two issues a year, lithoprinted, each issue being about 35 pages in length. Material for the first issue is now ready to go to press. This issue is devoted primarily to the beginning mineralogy course. In order to meet publication costs the Assn. is now soliciting advance subscriptions. The annual rate is $2. No reduction is at present allowable for membership in the Assn. All subscriptions must be paid in advance. Send check or money order to William F. Read, editor, Assn. of Geology Teachers, Dept. of Geology, Lawrence College, Appleton, Wis.

Industrial Plant Location—Its Application to Zinc Smelting. By Carl Hayden Cotterill. Published through the courtesy of American Zinc, Lead & Smelting Co., St. Louis, 1950. $5.—A description of the zinc industry in the United States is used to demonstrate a scientific approach to regionally locating industry plants. Economic factors considered include: raw material, labor, power and fuel, market area, transportation, capital sources, laws and taxes, and technological requirements. Considerable space is given to describing various aspects of the zinc industry from the mine to slab zinc, and of zinc smelting from the viewpoints of technology, business, and geography. A case study is made of two widely separated zinc smelters which verifies the pattern of cost and profit advantage drawn up by the procedures worked out for the scientific location of plants. The author is a plant and process investigator for the American Zinc, Lead & Smelting Co. This is a limited edition of 250 copies. **Write to: Carl H. Cotterill, 1600 Paul Brown Bldg., St. Louis 1.**

Motion and Time Study, Principles and Practice. By M. E. Mundel. Prentice-Hall, New York, 1950. 457 P. $6.65.—This book is intended to provide a systematic, practical, and scientifically correct treatment of present-day motion and time study. It considers the development and application of the basic principles of successful work. Illustrative examples from a wide variety of industries and types of work demonstrate the highly important reasoning process involved in the application of procedures. Graphic analyses are presented in the form in which they would normally appear in practice so as to provide a working guide.

Geography in the Twentieth Century. Edited by Griffith Taylor. Philosophical Library, New York, 1951. $8.75.—The work of over 20 authors, each of whom is a specialist in the subject with which he deals, this volume studies the growth, fields, techniques, aims and trends of geography. The book is divided into three parts, the first dealing with the evolution of geography and its philosophic basis, the second concerned with studies of special environments and with advances in geomorphology, climate, soils and regionalism. The last part describes field work, sociological and urban aspects, the function of the Geographical Society and geopacifics.



Production Jet-Piercing of Blastholes in Magnetic Taconite

by D. H. Fleming
and J. J. Calaman

DURING 1950 the jet-piercing process was used commercially in the piercing of primary blastholes in magnetic taconite at the preliminary taconite plant of the Erie Mining Co., Aurora, Minn.

The Erie Mining Co. purchased a jet-piercing machine and associated equipment in 1949, and the machine has been in operation since its installation in the summer of that year. An overall view of the pit with the JPM-1 jet-piercing machine in operation is shown in Fig. 1.

During three months of 1949 and continuously since February 1950, production piercing took place under all pit conditions. By the end of October 1950, a total of 15,000 linear ft of hole had been pierced in an open pit handling an average of 1200 to 1800 tons of crude a day in one 8-hr shift. While it is recognized that this output does not approach the millions of tons a year planned for the developing Minnesota taconite projects, the machine as a unit has been operating under conditions probably more adverse than those that eventually will be encountered in the large operations. This pilot operation has permitted evaluation of the piercing problem in the full-scale taconite plant.

This paper describes jet-piercing process fundamentals, important features of the latest jet-piercing burners and machine, actual piercing results obtained, and new developments that give promise of materially increasing overall process efficiency.

To produce the blasthole, jet-piercing utilizes thermal energy, as contrasted with the application of mechanical energy in churn drills and jackhammers. The heart of the process may be termed a tailored flame produced by a rocket-type burner, thermodynamically similar in every respect to that of the giant rockets being developed for military purposes. The heat release in the combustion chamber of the burner is about 50×10^6 Btu per cu ft per hr as compared with 5×10^6 for most modern steam generators.* Combustion of liquid petroleum fuels (kerosine, diesel oil, or No. 2 fuel oil) with gaseous oxygen in the burner chamber at pressures of 100 to 200 psi results in temperatures of about 4300°F.

Expansion of the hot combustion gases through divergent nozzles produces high-temperature supersonic jets having measured velocities of about 6000 fps. Impinging the flame jets on rock causes a thin surface layer to expand and break away from the base as a result of the thermally induced stresses. This spalling action is aided further in chert and quartzite by the 0.82 pct volume change resulting from the δ to β quartz inversion at 1066°F.† The dynamic action of the jets whisks the spalled rock

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* John H. Perry: Chemical Engineer's Handbook (Third Edition), p. 1639.

† R. B. Sosman: The Properties of Silica, Chap. XX.

Fig. 1—The pit at Erie Mining Co., Aurora, Minn., with the JPM-1 jet-piercing machine in action.

out of the path of the flame and consequently exposes fresh surface to attack. Some fusion is likely to occur in broken rock subsurface or where the iron band is thick and consequently in greater concentration, but the depth of melt is shallow and is immediately blown away, quenched, and embrittled by the steam and water, broken up if need be by the hole sizer, and easily ejected. Slower moving flames, although capable of spalling rock, lack the energy necessary to remove initial spallings and thereby to expose continuously new rock surface. Consequently, operation of the piercing process depends on the combination of high heat transfer rates for rapid spalling and high kinetic energy of the flame to keep the cutting face clean.

Water, a vital ingredient of the process, serves three purposes. 1—It acts as a coolant to preserve the combustion chamber and nozzles. 2—The cooling water is discharged near the bottom of the hole where it quenches and embrittles any material that may have been fused by the flame. 3—The waste heat in the combustion products flashes a large portion of the water to steam, which in turn functions as the conveying media for lifting or ejecting the cuttings continuously from the hole. The combustion gases alone could not do this job. The appropriate ratio of steam to combustion gases is 8:1.

Piercing Technique

The burner is mounted on the lower end of a blowpipe, the length of which is slightly greater than the maximum depth of hole to be pierced. As it is advanced into the hole the blowpipe is rotated to expose uniformly the rock in its path to the action of the flames. The rotation also helps to maintain a straight hole. If ore or rock to be pierced were uniform in composition and solid in formation, the blowpipe advance could be synchronized directly with the spallability of the rock for a given burner. If such were the case, constant high piercing rates would be obtained. For example, when solid sections of taconite are encountered, the piercing rate has been increased to as high as 60 ft per hr. However, this ideal condition is never obtained in normal pit conditions for three reasons: 1—The ore is not uniform in character, since there are alternate bands rich in silica or in iron; 2—There are holes, natural cracks, and cleavage planes; 3—Blasting will produce backbreak that must be passed through. The rock structure discontinuities lower the piercing rate and require control mechanisms to indicate their presence and special operating techniques to pierce them.

To illustrate the effect of discontinuity in the rock, consider the simplest case, an open horizontal crack or seam as shown in Fig. 2. In solid rock, *A*, the bottom of the hole directly under the flames generally assumes a hemispherical shape when using the conventional-type burner, which has one flame parallel with the blowpipe axis and one or more flames at an angle with the axis. The advancing hole, *B*, breaks into the crack with a small hole. The axial flame will jump the gap and start working on the adjacent rock face, the angle flames will continue to spall the triangular wedge of rock but at a reduced rate. Spalling does not readily take place on sharp corners or acute angular areas; in fact, in some instances, melting will occur. The blowpipe will advance until the end of the hole sizer starts to ride on the restriction, or collar, as it is commonly called. This causes part of the blowpipe weight to be transmitted to the collar; tension in the blowpipe suspension cable is reduced correspondingly over normal cable tension when the blowpipe is hanging free.

An instrument in the operator's cab constantly indicates cable tension. When cable tension drops below a critical point, which occurs when a collar is encountered, the operator stops the blowpipe advance, then retracts the blowpipe, *C*, a specific predetermined distance, 2 to 5 in., depending upon the particular burner design. The blowpipe is held at the retracted level for 10 to 30 sec while the angled flames burn out the restricting collar. The blowpipe then is advanced to the point of maximum advance and, if no drop in cable tension is noted, blowpipe advance, *D*, is continued; otherwise, the collar cutting cycle is repeated. If the operator finds that collars are occurring too frequently, the advance rate of the blowpipe will be cut back. On the other hand, when the blowpipe is running free, the operator will gradually increase the advance rate to achieve a high average piercing rate.

An ammeter in the rotary drive motor circuit also keeps the operator informed of developments in the hole. Nominal increases in rotary drive torque occur when a collar is encountered. Sometimes rubble will cave in on the blowpipe, causing sharp increases in rotary drive torque, although there will be no decrease in cable tension. Under this circumstance, the operator will switch from low, 15 rpm, to high, 45

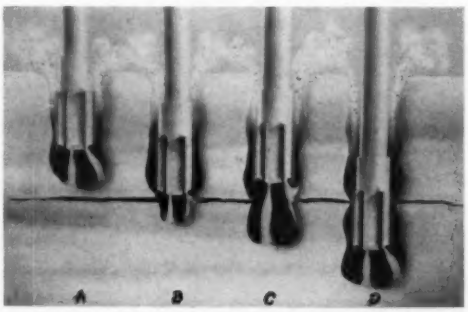

Fig. 2—Piercing through rock with a discontinuity—an open horizontal crack or seam.

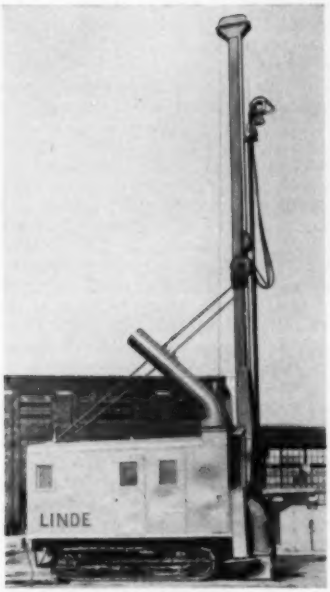

Fig. 3—The first JPM-1 jet-piercing machine.

rpm, to grind up the rubble. These two instruments enable the operator to judge at all times what is occurring in the hole and control the blowpipe advance accordingly.

The primary purpose of a piercing machine is to provide a mechanism for suspending, rotating, and controlling the advance of the blowpipe. In addition, the machine must be capable of rapid moves between holes and quick setup and leveling; it must provide means for metering and controlling the flow of oxygen, fuel, and water and provide means for exhausting the effluent gases from the top of the hole.

The first production jet-piercing machine, shown in Fig. 3, is now being used by the Erie Mining Co. The power supply is 440-v, three-phase, alternating current brought to the machine through a trailing cable according to conventional open-pit practice. The schematic machine cross-section in Fig. 4 shows the major components. The totally enclosed cab is mounted on caterpillars, which give a fixed forward or reverse speed of ¾ mph and are driven by a 40-hp motor. The 48-ft mast, kept in a vertical position for all but the longest moves, is raised and lowered by a winch actuated by the main drive motor. On the forward side of the mast are track guides that stabilize the blowpipe in its vertical travel. Hydraulic jacks ensure rapid leveling of the machine after it has been positioned over the hole marker. The average time for a hole-to-hole move, including leveling, is 15 min.

One of the most important machine components is the blowpipe winch, which pays off the blowpipe at a controlled speed and provides a means for indicating cable tension. A high and low speed range is provided. The low-speed range, which is infinitely variable between ¼ and 24 in. per min, is used for blowpipe advance. The usual operating range is from 3 to 6 in. per min. The high-speed range is used for backing away from collars and retracting the blowpipe from the hole. Although a high-speed range of 20 to 60 fpm is provided, the high speed is generally held fixed at about 30 fpm.

The blowpipe passes through and is rotated by the rotary table by means of drive pins that slide in the blowpipe flutes as the blowpipe moves up and down. Rotational speeds of 15 and 45 rpm are provided. The lower speed is used for normal operation, as previously mentioned, and the high speed is used in a tight hole or when rubble falls behind the blowpipe.

Jet-Piercing Blowpipe

The blowpipe, shown in Fig. 5, consists of three main components: the swing joint, kelly, and burner assembly. Oxygen, water, and fuel are introduced into the rotating blowpipe through the swing joint. This vital part of the assembly is precision-machined of selected grades of stainless steel to give adequate corrosion resistance and minimum wear. The suspending bail is attached to the main thrust-bearing housing, which is located immediately below the swing joint. The blowpipe guide blocks, which ride in the mast track, are attached to the thrust-bearing housing. The round, triple-fluted kelly is standard oil-well drilling equipment.

Oxygen and fuel are carried through separate tubes on the inside bore of the kelly to the burner assembly. Water is brought to the burner in the remaining space inside the kelly. The burner assembly consists of four main parts: the header, fuel injector, burner, and hole sizer. The header is a permanent part bolted to the bottom of the kelly onto which the fuel injector and burner are screwed. The liquid hydrocarbon fuel is atomized by kinetic impact of the gaseous oxygen as it enters the rear end of the pear-shaped combustion chamber. The burned gases are exhausted through divergent nozzles to produce the piercing jets. Oxygen and fuel flows are 10,000 cu ft per hr and 40 gal per hr, respectively.

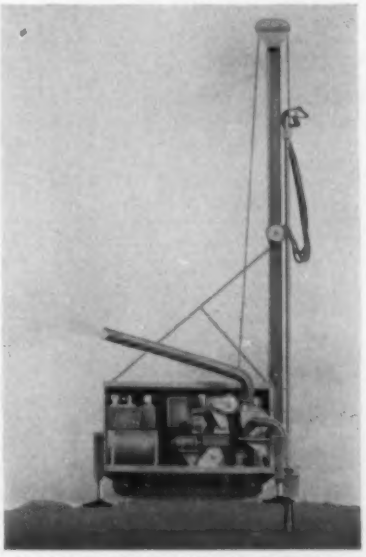

Fig. 4—Cross-section of the jet-piercing machine.

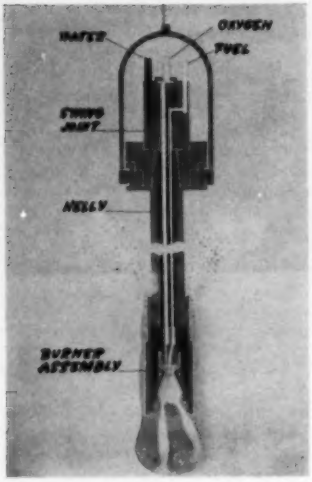

Fig. 5—The blowpipe consists of three main components, the swing joint, kelly, and burner assembly.

These flows have been fixed as the optimum for piercing the 6½-in. minimum diam holes now being made. If the flows are dropped substantially below this figure, the piercing rate is decreased to the point where labor and equipment costs are too large in the overall cost picture. Above these flows, commensurate increases in piercing speed have not been obtained.

The hole sizer, functioning also as a water jacket, encloses the header, fuel injector, and burner. It is constructed of heavy-wall steel tubing. Longitudinally welded to the outside surface of the hole sizer are heavy steel ribs or teeth whose top and front surfaces are coated with Stellite hard-facing material. The ribs extend a greater distance beyond the end of the hole sizer tube than the burner so that the burner front cannot be carelessly wiped on the bottom of the hole. The hole sizer takes the brunt of abrasions in the hole from cuttings, rubble, and scraping on collars. The Stellite alloy on the ribs is touched up after 70 to 90 ft of hole and brought up to gage on the front end where most of the wear takes place. After 11 to 12 hard-facings with Stellite alloy, the front end of the hole sizer shows some heat checking, which can be remedied by a light machining cut or welding in a new front section. The cooling water passes between the inside of the hole sizer and the outside of the burner and is discharged across the front face of the hole sizer. By so locating the cooling water discharge, the steel hole sizer is not damaged by backwash of the flames. The hole sizers are removed from the kelly by a power wrench.

Fig. 6—Triple-orifice burner used in 1950.

The jet-piercing burner is the key to good process economics. The number, location, and angularity of the flames with respect to the blowpipe axis, together with lesser variables such as combustion chamber shape and fuel injector design, have been the subject of much development work to achieve the most efficient combination of variables. So far, a total of 25 different burner types have been designed and tested. The most satisfactory has been the triple-orifice variety shown in Fig. 6. This type of burner has been in use for most of the 1950 season. It has shown an overall cost reduction of 20 pct in terms of cents per ton of ore in front of the shovel over 1949 designs because it will pierce a larger hole, 6½ in. against 6 in., at no sacrifice in speed and no increase in oxygen and fuel consumption. For purposes of comparison, the 1949 design is shown in Fig. 7. A most important corollary advantage of the 1950 design is a proven life expectancy of 3800 ft of hole against 300 ft of hole for the 1949 burners.

The flow of oxygen, fuel, and water is controlled by a lighting sequence switch in the operator's cab, which actuates solenoid valves in the respective lines. The burner is ignited by the machine helper who passes a kerosine flare under the burner while the machine operator performs the proper lighting sequence. After lighting, the helper makes minor flow corrections to maintain established flow conditions. Direct-reading, float-type meters are used.

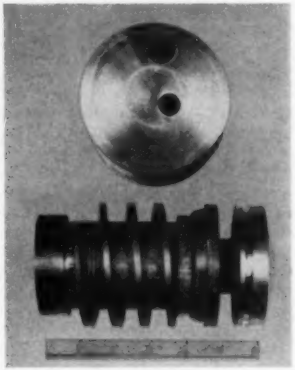

Fig. 7—An earlier design of dual-orifice burner used in 1949.

Process Fluid Supply

In the present operation, oxygen is supplied from a Cascade oxygen unit, as shown in Fig. 8, near the mine buildings. A pipe line runs to the pit where convenient taps are located. The lateral line, consisting of easily handled, 300-ft sections of copper tubing, terminates at a regulator in the pit. Connection to the machine is made by 150 ft of rubber hose from the regulator.

Kerosine or fuel oil is pumped to the blowpipe from a 500-gal storage tank built into the deck of the machine. This supply is adequate for two-shift operation. Fuel is brought to the machine by pipe and hose lines from a central storage unit or by tank truck.

Since it is planned to operate taconic properties throughout the year, a constant water supply is the

Fig. 8—Cascade oxygen unit near the mine buildings.

greatest problem. Temperatures of —40°F are not uncommon in Minnesota. In the present operation, water is brought from the mill reservoir to the pit in a pipe line buried below the frost line in the adjacent overburden. Along the side of the pit are located convenient outlets from which lengths of insulated pipe line, equipped for easy drainage, are laid on the surface to the drilling site. Connection to the machine is made by 150 ft of rubber hose. Water supply presents no problem in the warm season, but in winter weather, freeze-ups in the machine would occur if proper provisions were not taken during overnight or other protracted shutdowns.

In the present setup, the exposed water line is drained at the termination of the working shift, the hose from pipe line to machine is drained and stored inside the machine, which is heated around-the-clock by electric space heaters. The water tank, pump, and lines within the machine are drained. The blowpipe is purged with compressed air supplied by a compressor, part of the equipment of the JPM-1 machine. The burner and hole sizer are removed from the blowpipe and stored in a warm spot in the machine.

In the morning, as soon as the water hose is hooked up, the surge tank located in the rear of the machine is filled. About 5 gal of water are preheated to approximately 125°F in an electric heating unit in the machine. At the same time, the burner and hole sizer are being mounted on the blowpipe. The hot water is passed immediately through the blowpipe, followed by the cold pipe line water. Once flow is etablished, there is no problem of freeze-up. It is never stopped during the day's operation except for hole sizer changes. It is interesting to note that residual water left in the bottom of finished holes never freezes since it is well below the frost line.

Water failure or reduction of water flow before the critical point would destroy the burner; therefore, several safeguards are built into the machine. The water is fed into a 400-gal surge tank, which is kept full by a float valve. The pump drawing from the surge tank delivers 1000 gal per hr to the blowpipe at 80 psi. If the water level in the surge tank begins to drop, a warning light and buzzer in the operator's cab indicate that water adequate for only 20-min burning time remains. The second safeguard is a water-oxygen interlock that automatically shuts off the oxygen if the water flow drops below the minimum safe value for good burner cooling. This interlock, located between the pump and blowpipe, safeguards against pump or piping failure.

Approximately 50 pct of the water discharged in the hole during piercing flashes to steam and, as previously mentioned, it is this steam plus the products of combustion that carry the cuttings continuously from the hole. The steam and burned gases are exhausted from the working area in front of the machine, as shown in Fig. 9, by a 10,000 cfm fan driven by the 40-hp propulsion motor and discharged from a stack to the rear of the machine. The coarse cuttings drop out of suspension onto the ground around the top of the hole and are periodically shoveled out of the way by the helper. Fine cuttings are exhausted through the stack.

In many instances it is necessary to start a hole in broken and rubbly ground rather than in solid rock. In such instances the top of the hole, until solid rock is reached, will enlarge to a cavity that may be 2 ft across. This condition hinders proper discharge of cuttings because the steam loses velocity in this enlarged cavity and can no longer maintain the cuttings in suspension. The cuttings tend to boil around in the cavity and to prevent this the hole is cased to the depth of the cavity and the casing allowed to extend 4 to 6 in. above normal ground level, as shown in Fig. 10.

Piercing Results

Current mining operation is on a 25-ft bench with blastholes being drilled 5 ft below grade. The JPM-1 machine has a capacity for drilling holes of 31-ft maximum depth. In large-scale taconite operations, a higher bench is envisioned, probably around 35 to 45 ft; consequently, future piercing machines will require a higher mast and a longer blowpipe to accommodate this increased height of bench.

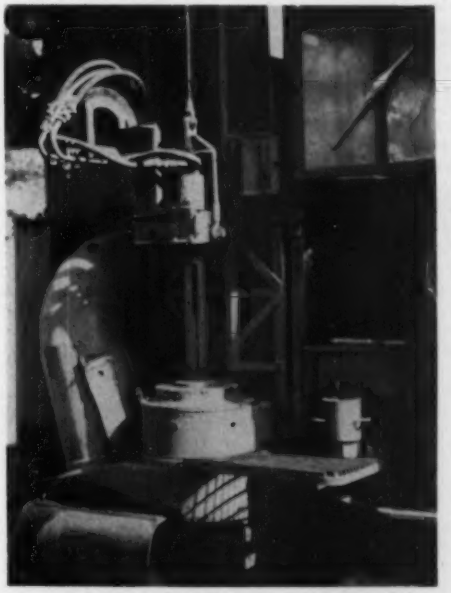

Fig. 9—Steam and burned gases are exhausted from the working area in front of the machine by a 10,000-cu ft per min fan driven by the propulsion motor.

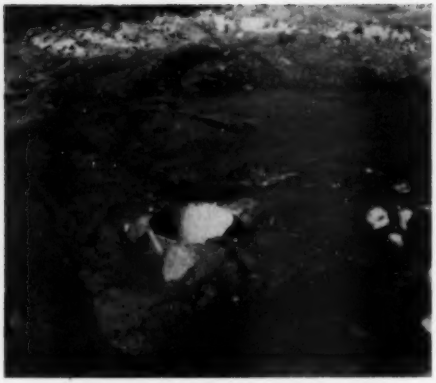

Fig. 10—A hole cased to the depth of the cavity. The casing extends 4 to 6 in. above normal ground level.

Table I shows operating results obtained in 1950.

In 1949 for the same oxygen and fuel consumption, the old-style burners would only pierce a 6-in. diam hole, which was loaded with 5½-in. explosives. In 1950, 6½-in. holes were loaded with 6-in. explosives and, a 20 pct increase in ore blasted per hole resulted. This improvement is the direct result of advances in burner design.

Preliminary tests also have been made with promising results on 7½-in. holes for 7-in. explosives. The 7½-in. hole was not used as a regular production item in 1950; however, it will probably be in much greater use during 1951.

Piercing represented by these results was done by regular mine labor, some of whom had been experienced in churn drilling. The technique of jet-piercing was learned easily by these men.

As is to be expected, drilling in solid rock gives the highest process efficiency. As a matter of fact, some holes have been drilled at rates exceeding 30 ft per hr. In bad backbreak, the piercing speeds occasionally drop to 30 pct of those obtained in solid rock.

Where pit conditions permit, it has been found desirable to utilize double-row piercing to bring down a greater tonnage per blast and to realize economies of piercing a second row of holes where the backbreak is minimized. Piercing speeds in the second row have averaged 8 pct higher than speeds in the first row.

Fig. 11—Explosives being loaded into the hole.

During the summer of 1950, drilling was started for the second lift in the new taconite pit at Aurora. It was necessary to drill through the top 4 or 5 ft of broken rock that lay on some areas of the quarry floor. Piercing through this layer of rubble was about 30 pct slower than when starting on solid ledge. The top few feet of 65 pct of the holes pierced in this area were cased.

It has been found necessary to pierce a hole with a minimum diameter ½ in. greater than the diameter of the explosive to be placed in the hole. Under these conditions explosive loading, as shown in Fig. 11, proceeds without difficulty. Both gelatin dynamite and Nitromon have been used for blasting jet-pierced holes. The load factor, i.e., pound of explosive per cubic yard of burden, used with jet-pierced holes is equivalent to the load factor used with holes produced by other methods of drilling.

A check on 20 holes showed a maximum temperature of 154°F immediately after piercing. This temperature was measured in the vapor zone immediately above the residual water that remains in the hole. The depth of residual water has varied from 6 in. to 8 ft, the latter is the exception. Many of the holes have been loaded within ½ hr after piercing.

Table I. Jet Piercing Operating Results

Avg piercing speed, ft per hr	15
Hole size, minimum in. diam	6½
Explosive cartridge loaded, in. diam	6
Approx. breakage, tons per ft of hole	24½
Approx. oxygen consumed per ft of hole, cu ft	660
Oxygen per ton ore, cu ft	27
Kerosine consumed per ft of hole, lb	18.3

Visual sighting indicates that rather than being smooth, the hole is corrugated. It was desirable to determine the extent of these corrugations and their effect on overall hole volume in order that the possibility of effectively utilizing this extra hole volume might be studied fully. A simple device was made and from the data thus obtained contour measurements were plotted. Illustrated in Fig. 12 are a 6½-in. minimum diam jet-pierced hole and a churn drill hole made with a 9-in. bit. By and large the jet-pierced hole substantially exceeds the minimum diameter set by the reamer teeth. Seventeen 6½-in. holes contoured had an average diameter of 9.3 in. The hole diameter produced is actually a function of the piercing speed: the greater the piercing speed, the lower the average diameter. This is to be expected since there is a relatively fixed relation between the cubic feet of oxygen used to pierce the hole and the cubic inches of rock removed per cubic foot of oxygen. Where the piercing speed is slow because of backbreak and rubble, the average diameter of the hole is consequently larger because piercing time is greater and more oxygen is used.

It is interesting to note that the churn-drill hole is not smooth-sided and has an average diameter of 11.6 in.

Maintenance and Supply

The problem of machine maintenance is one of considerable interest. The JPM-1 jet-piercing machine is the first of its type. It was over-designed to meet as many operating conditions as could be fore-

seen. While the machine is not perfect, no basic shortcomings have developed. However, excessive wear has been encountered in the exhaust fan scroll casing and impeller, and steps will be taken to overcome this. Kelly wear has also been substantial. The lower end of one kelly has been worn down ½ in. on the diameter in 10,000 ft of piercing. This will be remedied either through building up plus hard-facing procedure or removing the short worn section and welding in a new length. The turntable must be more rugged and larger to accommodate casing pipe. New production machines will have the same components that were included in this first unit. The mast will be higher and will be provided with heavier bracing for rigid hole-to-hole moves. The higher mast probably will dictate a broader machine base to maintain stability. Equipment arrangements will be simplified to permit easier access for maintenance, routine inspection, and lubrication.

The matter of process supplies for full-scale versus pilot plant taconite production is under consideration. Because of the scope of large-scale operation, circulating water pipe lines probably will be mandatory, with provisions for heating the water in cold weather. The main supply line probably will be buried below the frost line and back of the working face. Lateral supply lines that can be drained during periods of no operation will bring water to the rigs. Driox oxygen installations will readily supply the large volumes required and also permit great flexibility in demand loads. Fuel will be brought to the rig either by tank truck or pipe and by hose line direct to the unit.

Cost

In the present small operation, oxygen is much the biggest item of cost. This will change as the mining operation expands. It is common industrial practice for oxygen to be sold on a sliding scale basis—the more used, the lower the unit cost of the oxygen. This factor bears directly on piercing cost, all other things being equal. The bigger the mining operation, the greater the oxygen consumption and consequently the lower the jet-piercing cost. On the present scale of operations, piercing costs per ton are about on a par with churn drilling.

There are certain hidden economies accompanying the use of jet-piercing. A jet-piercing machine at present is doing the job of about eight churn drills. In an area such as northern Minnesota there is insufficient housing for the influx of workers who will be needed for the full-scale taconite plants. Directly or indirectly, the mining companies will have to take care of these needs. At least ten times more housing would be needed for churn drilling than for jet-piercing workers because of the extra help required with bit dressing, trucking, and the like.

New Developments

Certain developments now being tested hold great promise of making previously quoted production figures obsolete. The most important of these from a management standpoint is the development of completely automatic control of the piercing operation. When collars or restrictions are encountered in the hole, the machine senses this automatically, retracts the blowpipe a given distance for a predetermined amount of time, and then readvances past the restricted spot. The machine can be set, therefore, for the most efficient operating condition, and the human factor will be substantially eliminated. The first automatic control arrangement is being tested on the present machine, and substantial improvements over this first arrangement are expected.

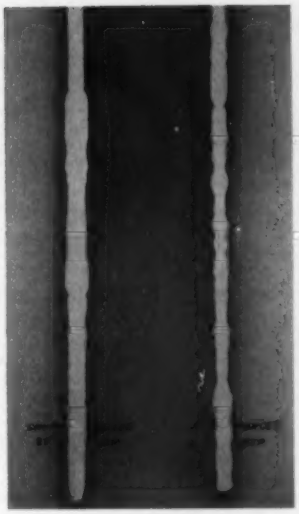

Fig. 12 (Left)—A churn-drilled hole made with a 9-in. bit. (Right)—A jet-pierced hole made with a 6½-in. hole sizer.

An important feature from the process standpoint is a technique known as hole enlargement, which allows the piercing of a wide range of hole diameters with one machine, changing only the burner and hole sizer. This technique requires first that a pilot hole be drilled to the required depth. Referring back to the hole contour chart, it will be noted that the amount of material to be removed in increasing the diameter of hole 1 or 2 in. over its minimum diameter is quite small. For instance, with a 6½-in. diam pilot hole, the amount of material to be removed to make a minimum 7½-in. hole is only about 3 pct of the original hole volume. To make an 8½-in. hole, the volume to be removed is 6 to 8 pct. A special radial-type flame burner, with a hole sizer for the large diameter hole, is mounted on the blowpipe for enlarging a pilot hole. The blowpipe is dropped at maximum speed between restrictions and slowed down to cut through the restrictions. Speeds on this enlarging pass in making a 7½-in. from a 6½-in. hole have been as high as 69 ft per hr. The 6½-in. diam holes have already been enlarged to as great as 9¾-in. diam. Studies are being made to determine the optimum pilot-hole diameter in relation to the final enlarged diameter. The possibilities of such a technique provide a wide degree of flexibility in hole diameters in one piercing machine.

The drilling of blastholes has been one of the problems confronting the commercial development of magnetic taconites. There are strong indications that jet-piercing has met and overcome this problem by giving a high unit production per machine at a reasonable cost per ton of ore in front of the shovel. To these advantages are added the flexibility possible in hole diameters and the current development of automatic control in jet-piercing.

Recent Operating Improvements At Kennecott's Utah Copper Mine

by L. F. Pett

ALTHOUGH Kennecott's orebody has long been outlined, it is still necessary to define further its limits. This mine, long an advocate of churn drill methods, recently supplemented its practice by using a diamond drill. So far, the diamond drill holes have been along the main canyon floor which traverses the mine area. This zone, highly fractured, is cut by numerous friable quartz veinlets encountered within the porphyry. These veinlets, formed by filling contracted porphyry fractures with hot, siliceous, mineral-bearing solutions, are often more highly mineralized than adjacent porphyry. They pulverize on contact, yielding only slight amounts of core.

For this reason neither analysis of core recovered (amounting to 37.5 pct of approximately 10,000 ft of hole drilled) nor sludge analysis considered separately would give correct assays. The following equation has been adopted:

$$\frac{\text{actual weight of core} \times \text{core assay} - \text{theoretical weight sludge} \times \text{sludge assay}}{\text{actual weight core} - \text{theoretical weight sludge}} = \text{assay}$$

Drilling is done under contract. Collection of core and sludge samples together with double-checked assaying is done by the company. Microscopic, spectographic, and X-ray examination of rock specimen saved is carried on at the University of Utah. A fund, set up by Kennecott Copper Corp. at the University, has encouraged cooperation in solution of mining research problems.

The drill used is a Longyear hydraulic powered by a Waukesha 26-hp gasoline motor. A pump, Bean Royal type, is powered by a 7-hp Briggs-Stratton gasoline motor. Weight of unit is 4000 lb and is placed under tripod of 35-ft wood poles within a 25-ft sq area.

The following results have been attained:

Avg depth of hole drilled, ft	1215	
Avg drilling depth per 8-hr shift, ft	10.11	
		Core Size, In.
Avg depth of NC casing, ft	31	2 11/16
Avg depth of NX casing and size core, ft	178	2⅛
Avg depth of BX casing and size core, ft	427	1⅝
Avg depth of AX casing and size core, ft	585	1 5/32

Through the use of metal sludge collection boxes, 12 ft long, 18 in. wide, and varying from 12 to 24 in. in depth, sludge recovery has been maintained above 95 pct. Samples, both core and sludge, are assembled for each sample interval and averaged in 50-ft bench increments. Determinations for mineral values are made at both the mine and mill. Assay results varying in excess of 0.05 of copper assay values are rerun to determine correct assay.

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The organization chart for the Kennecott Utah copper mine is shown in Fig. 1. The Utah mine requires approximately four men per shovel shift to drill solid rock, properly slope banks, and trim loose material from the top of bench sections in making them safe for men and equipment working below.

During recent years, while the mine has been worked day and night, powder crews have worked day shift only. Series of toe holes drilled back of advancing electric shovels comprise approximately 70 pct of all mine drilling. These holes, spaced about 21 ft apart, have a depth of 24 ft. Of the footage drilled, 25 pct is for vertical holes either 24 or 28 ft deep, spaced about 28 ft centers along the top rim of banks. This combination of toe holes, using an Ingersol-Rand DA 35 drifter mounted on a tripod and the vertical holes using an Ingersol-Rand Type X71 wagon drill is standard practice above the pit elevation. These benches are 68 ft high, with a few exceptions, while benches below the pit elevation are 50 ft high and require very little drilling other than toe holes. Five benches, varying in height from 80 to 100 ft, require a combination of toe holes plus vertical holes and bank holes or electric churn drill holes. Bank holes using the DA 35 drifter and electric churn drill using Bucyrus-Erie Model 29T, account for 5 pct of feet drilled. Until the past year, drilling of fill material on upper levels was accomplished by churn drill method. Wagon drills are now used for fills because they can be set up and drill a hole an hour.

It is necessary to run an air drill 7 hr for each 8-hr shovel shift. Average drilling rates during the past year were as follows:

DA 35 drifter using 2 and 3-man crews	— 4.36 ft per man hr
X 71 wagon drill using 2-man crews	— 6.45 ft per man hr
DA 35 drifter bank holes, 3-man crews	— 2.53 ft per man hr
Bucyrus-Erie churn drill, 2-man crews	— 1.9 ft per man hr
Total mine avg	— 4.57 ft per man hr

Mine practice assigns powdermen to job locations where they perform all drilling and blasting work within the area. Almost as much labor is consumed in springing and loading holes as in drilling them. Average powder consumption is approximately as follows:

	Per Electric Shovel Shift, Lb
To spring and chamber holes	— 50
Blasting	— 500
Trim banks	— 50

One fifth of all powder used is Hercules hercomite bag powder while four fifths is Hercules gelamite 65 pct strength in 1¼ in. x 8 in. sticks. Frozen material, overhanging from top banks, creates a winter hazard to shovel operators and equipment. Experiments are being conducted with a high-speed Hercules powder in an effort to eliminate this condition.

Banks are trimmed by powdermen who lodge 8 or 10 bundles of powder, containing 15 or 20 sticks each, across the upper surfaces of each working face. To each bundle of powder is attached a primer with 6-ft fuse which is lighted as the powdermen, who have lowered themselves down the bank on ropes, ascend to safety.

Three angle dozers, D8 caterpillars, make grades and move supplies for the average 31 drilling machines working daily.

Compressed air is furnished by three Ingersol-Rand compressors, each with rated capacity of 3750 cu ft of air per min at 100 lb reservoir pressure.

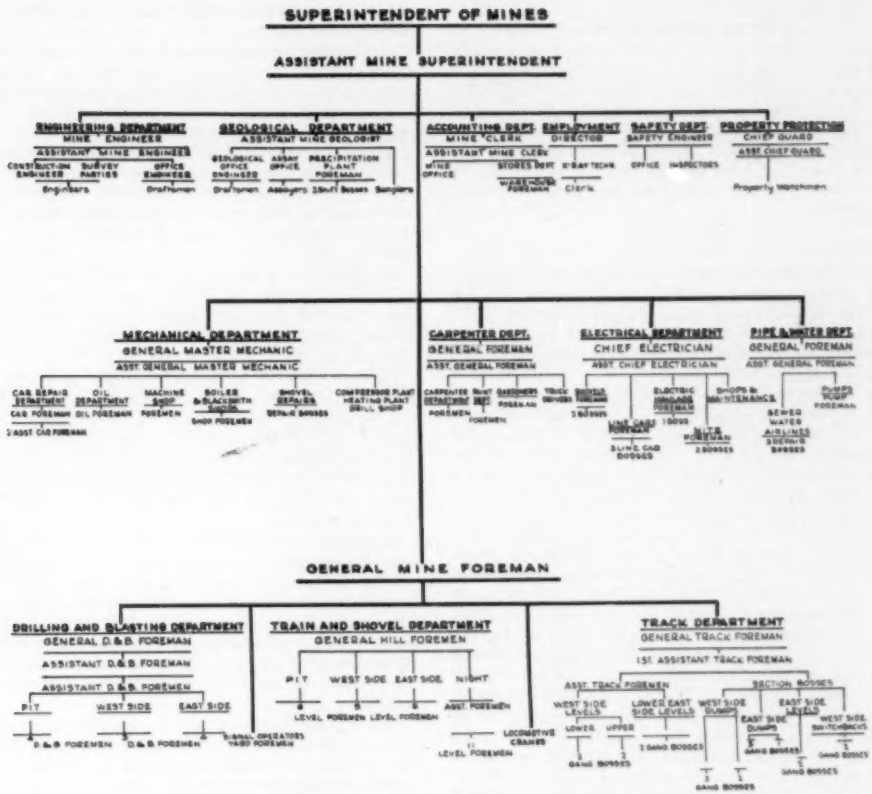

Fig. 1—Organization chart for the Kennecott Utah copper mine.

Numerous minute leaks encountered in normal distribution of the 65 miles of air line within the mine area cause excessive air loss, and unit drilling equipment and supplementary air supply are being investigated.

Track

Into the mine's labor pool come local high school boys, Mexicans, Japanese, Puerto Ricans and Navajo Indians, and from this pool emerges the mine's track department. After the men obtain a few weeks experience, they begin to leave the track for higher paid jobs via a seniority bidding system. Unskilled labor and increasing costs have forced machines to usurp many tasks previously done by well-trained track gangs.

Table I. Increase in Operating Efficiencies

	1937	1940	1948
Ore and waste loaded, tons	51,427,000	56,838,000	53,300,000*
Mine stripping ratio	1.223	1.19	1.369
Track lined per trackman shift, linear ft.	30.5	35.3	42.7
Waste dumped per trackman shift, cu yd	180	287	449
Wage rate per trackman shift, $	4.30	4.30	8.89 (6 months) 9.85 (6 months)

* First 9 months of 1948.

The Utah mine has not yet found a way of replacing track ties, maintaining track gage or superelevation by machine methods, but its track department has undergone considerable mechanization. Track department workmen are divided into the following three groups: men in gangs, 60 pct of the total; switchtenders, flagmen and yard cleaners, 30 pct; and operators of track machines, 10 pct.

Work assigned to the track department requires approximately 17 men per shovel shift. Among switchtenders and flagmen are many employees who, after long company service, have returned to these ranks. Extension of centralized traffic control on ore haulage switchbacks will remove a few of these men by pushing younger and more able-bodied men back to gang labor.

The company's program of replacing 65-lb steel on level bench tracks with 90-lb steel and changing 90-lb steel to 131 and 132 lb on ore haulage switchback is nearing completion. To date, 45 miles of track have been replaced by heavier steel. This program, initiated because of increased tonnage of ore and waste cars, also permits higher speed traffic to match longer ore and waste haul.

The years 1937, 1940, and 1948 are comparable in mine output and offer comparison in track mechan-

Table II. Hoist Cables Used

Number of Hoist Cables	Construction [a] [b]	Cost Per Ft	Cu Yds Loaded, Avg
63	6 x 19	0.818	164,833
62	6 x 29	1.003	233,101
64	6 x 37	1.032	243,994
407	6 x 41	1.083	236,136

[a] a—Strands.
[b] b—Wires per strand.

ization effected in dump maintenance, necessary for waste disposal, and lining bench line track in shovel pits. The 99,000 track shifts required during 1937 were reduced to 68,000 shifts by 1940 and further reduced to 46,000 shifts during 1948. Table I shows progress made in these years.

The period from 1937 to 1940 reflects introduction to full coverage of angle dozers for level grade preparation as well as filling and grading of dumps. D8 caterpillars using 11-ft blades were adopted for bench lines while D7 caterpillars using 10-ft blades were originally used on dumps because caterpillar treads corresponded to track gage. D7 caterpillars were replaced with D8 machines on dumps. The more recent progress was the result of the introduction of miscellaneous equipment. A caterpillar, diesel No. 12 motor grader, increased feet of track lined per track shift by 27 pct during the past year. This machine adjusts track superelevation to curvature and practically eliminates raising track for grade adjustments. Jackson electric tie tamper units, Model M2, with a 4 to 6 hp gasoline motor driving a 2.5-kw generator, delivers 60-cycle, 110-v ac to vibrating tampers with 6-in. blades. These units boosted feet of track raised and tamped per track shift 31 pct and improved track surface. Spike pullers, spike drivers, pavement breakers, power track wrench, rail grinder, and welder are used by mine track crews.

Shovels

Since tonnage per shovel shift signalizes the degree of success in open-cut mining, more shovel power without sacrifice of mobility was sought. The Marion full-revolving shovel, Type 4161, with 5-cu yd dipper, 1⅜-in. hoist cable carrying 100,000-lb bail pull, in conjunction with 40-cu yd waste cars, 100-ton ore cars and 85-ton dc locomotives is the Utah mine's nucleus of production. Three-man shovel crews and two-man train crews are used.

Six shovels have been purchased with dual operating compartments. These compartments increase maintenance costs but were adopted because they increase the safety of operating crews.

Amplidyne control systems have been furnished as standard equipment on four shovels. No appreciable increase in loading has been made by these shovels. A slight operators' resistance to shovel kick-out on stall or overload exists. Excessive heat developed in the grid control panel, as a result of carrying higher and more uniform sustained voltage than Ward Leonard system, will probably require an additional exhaust fan on the roof immediately above the grid panel. Difference in size and use of electrical contacts reduces electrical maintenance work. These shovel controls have not been used long enough for conclusive mechanical maintenance comparison but indications point to a substantial reduction in mechanical maintenance on Amplidyne shovels.

One shovel house has been rebuilt in an effort to add rigidity to house protection. Five-in. H-beams, spaced 4-ft centers along sides and arched top, support 5/16-in. plate on house covering and ½-in. plate on operators compartment. Cost of this change is approximately $5000 per shovel. Three serious accidents focused attention toward additional house support. It is anticipated that such shovel housing will be adopted in future construction with present houses converted as rapidly as mine crews can make the change.

Replacement of shovel parts most frequently worn includes hoist cables, dipper sticks, dippers, latch plates, and dipper teeth. Experiments are being conducted on 6x46 hoist cables but results are not yet conclusive.

Dipper sticks with inside handle used on Type 4161 shovels show wide variation in yardage loaded, but an average of 1,343,000 cu yd per handle was loaded during the past five years. Most common point of failure is midway along the handle which may be caused by the mine's practice of starting swing movement as soon as the hoisting operation is in full motion.

Except for three dippers of the Marion type, American Manganese 5-cu yd dippers are standard on revolving shovels. Dipper changes, which are listed in terms of change of dipper front, have been made after an average loading of 517,000 cu yd. Approximately four latch plates are used for each change of dipper front. A set of dipper teeth is required for approximately each 100,000 cu yd of ore or waste mined.

Ore at depth in relation to remaining ore above the pit elevation makes mandatory increased speed in carving 50-ft benches below present working levels. During recent years these levels have been established in about 18-month intervals. A Marion shovel, Type 4161, equipped with 35-ft boom and 5-cu yd, short bail dipper has been used to dig a shelf 6 ft deep. Successive drop cuts follow each track line, toe hole blast, and electrification cycle. Past practice has been to form, roughly, a circular loop 800 to 1000 ft in diam before beginning a new level with its 1800 ft of 3 pct switchback and 1000 ft of level room.

Last year, in an effort to increase progress, the bottom ore shovel was placed on a three-shift basis with shovels on adjacent levels working two shifts daily. To further augment this program, the company is purchasing a Marion 45-ft boom with 32-ft dipper sticks and 4-cu yd dipper, which will replace a standard boom and accomplish the 50-ft drop in a series of three cuts rather than the present nine. Wagon drills with vertical hole drilling will replace the present toe hole method of shooting solid material.

Electric power comes from the company's 100,000-kw steam plant 15 miles distant. Power at 42,500 v, three phase, 60 cycle, is received over two circuits of No. 4/0 bare copper conductors supported on steel towers. Copperweld static wires are used to protect these lines from lightning. Four substations with transformer capacity of 26,750 kw are strategically located for power distribution. Substations No. 1 and No. 2 are located on opposite rims of the mine working benches. Each station has two banks of three phase, 1200-kw Maloney transformers con-

nected in parallel. Connections are delta-delta 40,000 to 5500 v. From each station emerge four, three-phase, 5500-v ac feeder circuits stretching finger-like to touch opposite ends of each mine level in supplying power to 42 electric shovels. Bench lines traverse each level, end to end. Power lines leading to shovels are three phase, No. 2, bare copper wire carried on movable steel towers. Lines are energized only to point of contact with the shovel's trail cable. As the 5000-v power lines leave feeder taps to enter the level bench lines, they pass through a 7500-v, 600-amp, three-pole, oil-circuit breaker having an overcurrent trip attachment. These switches are manually operated. In leaving substations, feeder lines pass through a General Electric oil circuit breaker of 15,000 v with a 400-amp rating. These breakers have three-pole automatic overload tripping which is controlled by General Electric Type 1 AC induction time overcurrent relays. Breakers trip instantaneously on short circuit, and in 3 sec at 650 amp for sustained overload. Being closer to the source of power and more sensitive than bench line equipment, station breakers normally trip ahead of bench line circuit breakers, unfortunately putting out of service a group of shovels.

Rotary Converters

Mine haulage electrification was established on a basis of 750-v dc. This current is supplied from four substations spaced to meet feeder requirements. Stations 1, 2, and 3 use synchronous rotary converters. These machines, ten in all, are Westinghouse converters of 1000 kw 750-v six phase 900 rpm with overload rating of 150 pct for 2 hr and 200 pct for 30 min. All converter stations have automatic switching and control equipment. However, a station attendant is maintained on day shift. An Exide battery, Type EMGO, 7-plate, 120-amp hr capacity with 120 v, is used for control energy. A Westinghouse M.G. set, 440 v, 3-phase, 5½-hp motor with generator rated 3½ kw on 125 v, is used to charge the station battery. Direct current from each substation is delivered over million circular mil feeder lines to the various trolley circuits. A circuit breaker, Westinghouse, Type CH, 2000-amp, 750-v, air break equipped with automatic short circuit detecting resistance is placed in each feeder circuit.

Because of excessive heat liberated by converters, it was found necessary to install a forced ventilation system in No. 3 station during the past year. Air is drawn through filter by fan, which forces air through ducts leading to each machine. Five or six air changes are made per hour. Heated air escapes through ventilators on the roof. This circulating air dropped temperatures 8° to 10° during warm weather.

Mercury Arc Rectifiers

Substation No. 4, placed in service during the past year, provides power for ore haulage to the newly electrified main line assembly yard. It is equipped with two 750-kw mercury arc rectifiers in place of synchronous rotary converters. The Ignitron rectifiers are six tube, Westinghouse Type 1 P.G. 36, 750 v. These machines do not require a station attendant, but equipment receives daily inspection. The only difficulty experienced has been caused by occasional power interruptions. Instead of waiting for the temperature to reduce and permit automatic closing of switches, an electrician closes them manually. Pressures within tubes rise rapidly when power interruption occurs. Reducing this pressure by vacuum pump normally requires 10 to 15 min. These occasional interruptions are bridged by a million circular mil tie between the No. 3 substation, with rotary converters, and switchback and yard normally supplied from the arc rectifier substation. Absence of moving parts, elimination of daily station attendant and flexibility of overload amounting to 150 pct for 2 hr and 300 pct for 5 min have proved these machines well adapted to mine service.

Mine Haulage

Sixty-seven 85-ton General Electric locomotives, having a 250-hp series motor mounted to each of four driving axles, are used in mine haulage. These locomotives have a tractive effort of 42,000 lb when trolley carries 750 v. Drop in voltage brings a corresponding reduction in available effort. Maximum tractive effort is based on a speed of 10 miles per hr. Each locomotive is equipped with a compressor capable of furnishing 150 cu ft per min at 130-lb reservoir pressure providing ample air for the average 7.3-mile ore haul over grades varying from 3 to 4 pct. Gear ratio between motor pinion and shaft gear is 85 to 18 or 4.72 except on one locomotive which has a gear ratio of 76 or 4.47. Each locomotive carries side arm collectors with height range from 18 to 20 ft which are used on work levels. Overhead pantographs having effective height variation from 18 to 24 ft are used on switchbacks and tracks beyond working levels. Empty ore trains, consisting of a locomotive and 16 ore cars, travel up 3 and 4 pct switchbacks while loaded trains have from 15 to 22 cars on return trip down grade. Empty ore cars, weighing 25 tons, are loaded with 91 tons of ore. Speeds vary from 8 to 10 miles per hr up grade or over working levels and from 10 to 20 miles down grade. Because of the increased length of haul for ore trains and resultant over-heating of electrical equipment, ventilating blowers are being installed on locomotives in this service. Two 3½-hp blower motors, one for each truck, will draw air through filters and deliver 3000 cu ft, which will be divided between two drive motors and the enclosed grid compartment. Increase in width of motor pinion and gear teeth is being considered, as is an increase of motor drive shaft from 4 in. to 4½ in., in an effort to reduce shaft deflection, a frequent cause of gear failure.

Waste Cars

While both 30-cu yd and 40-cu yd waste cars are in service, the company's present program is expected to provide ample 40-yd cars within two years. Waste trains, consisting of locomotive and seven waste cars travel over switchbacks varying from 3 to 5 pct. Locomotive compressor provides air for brakes and dumping cars as well as furnishing air for a light generator. The waste trains are loaded by shovels and then pushed by the locomotive towards the dump. At night the locomotive headlight is not visible over top of loaded cars, so that additional light must be provided along track ahead of moving cars. Air generators, Ingersol-Rand, size AL 150, are used in delivering 115 v to a 150-w lamp inside seal beam container. This lamp, hanging from the front end platform, furnishes sufficient illumination for a distance of 250 ft.

Felpax journal lubrication has recently been installed on ore cars and 40-yd waste cars. This lubrication improves car journal wear and practically eliminates cold weather hot boxes.

A G.R.S.* centralized traffic control system has been incorporated into the mine's ore haulage switchback system. Information concerning position of switches and location of trains is provided by light indicators on two control panels. The lower control tower is located in the main assembly yard at Copperton, five miles north of mine terraces. From this tower main line trains with double unit, 250-ton electric locomotives handling 70 to 90 loaded ore cars are directed to either of two mill yards 12 miles away. Empty trains of equal length return from the mills, following centralized traffic control signals to Copperton yard. As mine locomotives leave this yard, with 16 empty ore cars, they enter mine switchback tracks under control of the central yard tower, situated midway between the mine and assembly yard. From this point empty trains fan out to various mine entrance levels. Loaded ore trains are likewise collected, and traffic between central yard and Copperton is over a double track system. Model 5B switch machines with 20 dc v rating are used to throw switches. Included in the present centralized traffic control system are 66 signals and 27 switches. Switch point heaters, using 220 v ac power, are installed with each switch. Track signal circuits are controlled by 8 v dc. Centralized traffic control equipment has speeded up traffic safely and eliminated 16 switchtenders and flagmen on mine tracks.

* General Railway Signal Co.

To provide immediate contact with electrical and mechanical maintenance crews, as well as operating personnel, 13 radio installations were made at the mine during 1948. Equipment includes four land stations and nine mobile units and was installed in connection with the Mountain States Telephone Co. With the exception of a 50-w mine office station, which receives its power from 110-v ac lighting circuit rectified, all stations are of 30-w capacity and receive power from a 6-v 160-amp hr storage battery. This power drives a motor generator set producing high frequency modulation necessary to transmit and receive voice messages. All stations operate on a single frequency to transmit or receive. Push button control, on handle of hand set, shifts station equipment to receive or convey signals. While the carrier frequency used is known as "line of sight radiation," messages carry over curvatures well beyond line of sight but quickly fade when an abrupt ridge separates stations. The four land stations can, by single relay, reach any point of the 150 miles of track. Mobile radio should tend to compress the mines sprawling operations and place them firmly in the hands of supervision.

Technical Note

Flotation of Diamonds

by R. G. Weavind, I. Wolf, and R. S. Young

ONE of the most important fields of investigation at the Diamond Research Laboratory in Johannesburg is concerned with improvements in metallurgical practices for the diamond mining companies, with particular reference to increased recoveries of the smaller industrial stones. Considerable work has been done on the possible application of flotation processes to the diamond industry.

From the viewpoint of recovery processes, diamonds in their natural state may be grouped into two classes, the water-repellent diamonds, which adhere to a grease surface, and the water-avid diamonds, which, because of their wettability, will not adhere to a grease surface and must be recovered by means other than the grease tables used for water-repellent diamonds.

Experiments in the flotation of small diamonds from both kimberlite and alluvial deposits indicate the following conclusions:

Water-repellent diamonds: Satisfactory flotation of —16 mesh diamonds, which are naturally water-repellent, may be accomplished using either Aerofloat 25 together with cresylic acid, or Du Pont B23 as frother together with kerosine as auxiliary oily conditioner or froth stiffener. The quantities of reagents required are of the order of 0.15 lb per ton Aerofloat and 0.18 lb per ton cresylic acid.

The use of acid circuits is detrimental, and for best results a pH between 7 and 9 should be maintained. A flotation period of 5 to 10 min is necessary to insure that all floatable diamonds are removed.

Diamonds larger than 16 mesh cannot be recovered satisfactorily by flotation.

Xanthates do not act as collectors for diamonds, and this is probably associated with their inability to impart a water-repellent surface to this mineral.

Water-repellent diamonds smaller than 28 mesh can be floated quite well by the addition of a frother alone, such as pine oil or Du Pont B23.

Water-avid diamonds: Partial flotation of the smaller sizes of wettable diamonds can be achieved by preconditioning with fatty acid soaps, cationic amines, and similar reagents, which will impart a water-repellent film to diamonds. Washing to remove excess reagent, followed by flotation, will result in a fair recovery, but the latter is much lower than for water-repellent diamonds.

Crushed boart: Recovery of crushed boart from the waste products of industrial uses is best accomplished by first conditioning the diamonds present in the mixture with fatty acids, cationic amines, etc., removing the conditioning agent by washing, and floating in a cell of the pneumatic type. Flotation reagents found to be most suitable are Du Pont B23, and Aerofloat 25 together with cresylic acid. The optimum quantities are 1.2 g Du Pont B23, and 0.55 g Aerofloat plus 1.4 g cresylic acid, per liter of pulp in the cell. A solids-to-water ratio of 1 to 4 is found to be the most suitable, and alkaline circuits are necessary for best results. Diamonds larger than 28 mesh are not recovered satisfactorily by this procedure, but for finer sizes flotation offers an excellent procedure for the reclamation of this strategic industrial material.

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Economic Significance Of Recent Technologic Research On Solid Fuels

by Arno C. Fieldner and Ralph L. Brown

PROBABLY no large industry in the United States is in greater need of technologic research leading to economic improvement than the coal industry. It has suffered severely from increasing substitution of petroleum and natural gas for coal and its products in the fuel markets. Part of this substitution is due to the greater convenience and suitability of liquid and gaseous fuels for special purposes, and part of it has been due to the extensive research programs conducted or sponsored by the petroleum and allied industries in the past 2 decades. A recent estimate[1] places these expenditures at $100,000,000 a year.

Expenditures on coal research and engineering development probably approximate $20,000,000 a year. The Government is expending about 25 pct of this amount on the production of synthetic liquid fuels from coal. Excluding synthetic liquid fuels, the total expenditures on coal research and development by all agencies, public and private, may be estimated at about $15,000,000. This is only 0.5 pct of the value of the coal production in 1947—688 million tons. This is a modest figure in comparison to the $100,000,000 a year spent by the petroleum industry; its expenditures are about 3 pct of the value of the production of petroleum for the same year.

From a superficial point of view, this comparison appears unfavorable to the coal industry. However, it must be remembered that even today only 15 to 20 pct of the coal production is processed in the manufacture of gas, coke, and chemical products. Eighty to eighty-five percent is burned raw or washed to reduce its content of sulphur and ash-forming minerals, whereas all crude petroleum had to be subjected to distillation or other chemical processing before it could be used. Such processing required the services of chemists and research engineers to make petroleum useful as a fuel or a lubricant. Research thus became a recognized essential for securing and increasing the markets for petroleum products, and naturally the idea of scientific research grew up with the industry and spread to exploration and production as well.

The principal problems of the coal industry were in mining the coal from the bed and handling it at low cost. Research on better utilization was left to the users—power-plant-equipment builders and operators, the coke and gas-manufacturing industries, and government and educational research agencies. Very few coal companies undertook research, unless they may have cooperated with manufacturers in developing better mining and preparation equipment.

This condition began to improve in 1930 when the anthracite-mining industry of Pennsylvania established a research laboratory to improve anthracite-burning equipment for residential and industrial heating. In 1933, the bituminous-coal industry likewise undertook to support bituminous-coal utilization research by establishing Bituminous Coal Research, Inc. Beginning with a small appropriation contributed by coal-mining and railroad companies and the Battelle Memorial Institute, the annual appropriation sponsored by Bituminous Coal Research, Inc. has grown to over a million dollars a year. It supports extensive utilization research at Battelle Memorial Institute, important fundamental research at The Coal Research Laboratory of the Carnegie Institute of Technology and coal research by other agencies. Through its Locomotive Development Committee it supports pioneering research on the development of a coal-burning gas turbine and through the Mining Development Committee it promotes research on a new type of continuous mining machine that operates without using explosives.

Other organizations have contributed major publications on fundamental and applied coal research in the last two decades, including the Minerals Industries Experiment Station of Pennsylvania State College, the Illinois Geological Survey and University of Illinois, the University of West Virginia, the University of Michigan, the University of Alabama, the University of North Dakota, the Massachusetts Institute of Technology, the Koppers Company, the U. S. Bureau of Mines, and, in recent years, the Institute of Gas Technology.

Engineering development work, which is included in the overall estimate of $20,000,000, is conducted largely by manufacturers of equipment, and this portion of the estimate is difficult to gage. It represents a large proportion of the estimate and probably is too small rather than too large. For example, the development of mobile coal-loading machines and continuous mining machines, outstanding in recent mining research, undoubtedly involved a high cost.

Coal Mining

From an economic point of view, the greatest research development in the coal industry obviously has been the growing degree of mechanization in mining. The percentage of underground-mined bituminous-coal output mechanically loaded has risen from 3 pct in 1926 to 67 pct in 1949. Coal operators and equipment manufacturers have united in designing machinery. Loading machines of large capacity and astonishing flexibility are in common use. Shaking conveyors transport coal from producing faces to transfer points from which it may be carried long distances underground and on the surface; and in many mines rubber-tired shuttle cars carry the coal from the loader to the

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train of mine cars or belts. The mechanical loader fills a shuttle car in less than a minute, and the shuttle car discharges its load into the mine car in 30 sec. Similar improvements have been made in drilling and blasting.

In the last few years the greatest achievement of all is being successfully demonstrated in the continuous mechanical mining machine that cuts the coal from the face without drilling or blasting. Under favorable conditions, this machine has increased the tonnage of coal mined per man employed at the face, 50 to 150 pct. An important new auxiliary being tried with the new Bituminous Coal Research mining machine is an extensible stainless-steel conveying belt using a conventional shaker-conveyor drive. A radically different type of continuous mining machine is the coal planer developed in Germany during the war. Coal is cut from the longwall face by a plane or plough drawn by a cable. The coal falls on a conveyor parallel to the course of the plough. It works best with the more friable coals, and the Bureau of Mines will test one in this country on thin beds in the low-volatile field of West Virginia in cooperation with industry.

From the point of view of improving safety in coal mining, an outstanding recent development has been the use of roof bolts to prevent falls of roof. Such falls have been for years the greatest single cause of deaths and injuries in mining coal. Roof bolting is accomplished by drilling holes into the roof and inserting mild-steel bolts about 1 in. in diam in the holes. The bolts are threaded at one end and slit at the other. They are anchored at the back end of the hole by driving the slit end of the rod over a steel wedge, which expands the end of the bolt in the hole. The bolts then are placed under tension by tightening the nuts on the threaded end on a bearing plate at the collar of the hole with a power wrench. The effect of roof bolting is to consolidate several thin strata to form a thicker and more competent beam across a mine opening than the thin individual stratum and thus prevent falls of roof.

During the past 2 years the Bureau of Mines, in cooperation with coal operators, has conducted extensive research on this method, and its use has spread rapidly. Practical experience has shown that roof bolting also improves operating efficiency at the face to a considerable degree and, therefore, may be regarded as an important factor in economic improvement of mining operations.

Preparation of Coal

The increased mechanization of mining has imposed additional burdens on the preparation of coal. Mechanical mining necessarily includes more ash-forming impurities in the coal than hand mining with good face preparation. However, these impurities are removed easily and more cheaply by mechanical cleaning plants on the surface. Coal washing also has become more essential because the best grades of coal are being rapidly depleted. In the last two decades the percentage of bituminous coal mechanically cleaned has increased from 8 pct in 1930 to 35 pct in 1949.

Probably the most important technologic development in coal cleaning in recent years is the heavy-medium process of washing, using a semistable suspension of finely ground solids as a flotation bath to separate good coal from refuse. The most popular type of suspension in use in the United States is finely ground magnetite in water. It has the advantage that the medium can be reclaimed and reconditioned with magnetic separators. A strictly American development in this method is the drum-type separating vessel, which is especially adapted to the treatment of large sizes of coal at high tonnage rates.

A relatively new special development of the heavy-medium process is the cyclone washer, a heavy-medium washing vessel in the form of a hydraulic cyclone. It was developed at the Dutch State Mines and is now in use in a few preparation plants in Europe. This cyclone is especially adapted to handle fine sizes of coal efficiently and is reported to be effective down to a size of ½ mm. The hydraulic cyclone is also being introduced widely as a water-clarifying and sludge-recovery device. For this purpose, hydraulic cyclones are fed with the washery water pumped into the cyclone at about 1 to 2 atm pressure. The size of primary cyclone units used for this work has been fairly well standardized at 14 in. diam, and such a machine will handle washery water at the rate of about 250 gpm. Larger cyclones may be used as classifiers to discharge the fine slimes in the effluent and recover the deslimed coarser sludge as a spigot product.

Smaller cyclones, down to as small as 3 in. diam, have been introduced to recover the very fine slimes. Some combination plants have been introduced in the past year to make a complete recovery of washery water, in which two sets of cyclones are used—the first stage consisting of 14-in. cyclones and the second of banks of 3-in. cyclones on the effluent water from the 14-in. machines. A relatively large installation of the Carnegie-Illinois Steel Corp. is operating successfully with the washery water in 100 pct closed circuit.

Another recent development of promising future importance is the kerosine flocculation method of cleaning fine slurries and dewatering the cleaned product. This method is an adaptation of the conventional froth-flotation process, using kerosine as the principal reagent so as to obtain a light froth that breaks easily and permits ready draining of the product. The system developed at the Southern Experiment Station of the Bureau of Mines at Tuscaloosa, Ala., now in commercial use at one of the washeries of Sloss-Sheffield Steel Co., uses a modified screw conveyor to clean and partly dewater the washery sludge at that plant.

In the preparation of subbituminous coal and lignite, significant progress has been made in research on the flash-drying of the fine coal in the entrained or fluidized state. Pilot-plant tests have shown reductions of bed-moisture content of lignite from 60 to 7 pct and less.[5] This is an important step in upgrading these low-rank coals and will reduce the cost of transportation by removing a large weight of water, which is of no use to the consumer.

Combustion of Coal

As research in the mining and preparation of coal has led to the most significant economic results in the production of coal, so has research in combustion, carbonization, and gasification of coal produced continually increasing economies in its utilization. Since about 85 pct of coal production is burned to produce heat or power, it is not surprising that the widespread research in combustion and fuel utilization of coal initiated in the early days of

the present century resulted in material economic returns to American industry. The great reduction from an average consumption of 3 lb of coal for the generation of 1 kw-hr of electrical energy by public utility power plants in 1920 to 1.34 lb in 1940 indicates the magnitude of these fuel savings. The cream has been skimmed from the possible gains that can yet be made in a modern public utility power plant. Nevertheless, in the last decade further reductions have been made to a figure of 1.25 lb per kw-hr. Also material progress has been made in developing equipment that can use low grades and various kinds of coal. The development of spreader-type stokers, water-cooled and slag-tap furnaces, cyclone combustion furnaces, and improved air preheaters and better understanding of the conditioning of boiler water to prevent scale formation and corrosion have provided very significant improvements in the operation of boiler plants.

With respect to residential and small commercial heating units, much progress has been made in recent years in providing smokeless and convenient automatic heat from solid fuels with stoker-fired, bin-feed, and ash-removal furnaces. Research on such equipment sponsored by the coal industry in the last 2 decades has borne fruit in recent years. Equipment including these improvements is now on the market, as are smokeless, hand-fired, magazine space heaters. These have become available at a time when a growing public demand for cleaner city atmospheres has led to prohibition of high-volatile bituminous-coal fuels unless burned in stoker-fired or other smokeless furnaces.

From the standpoint of future economic significance to the coal industry, a promising result of research in the field of combustion appears to be the powdered-coal combustion gas turbine sponsored by the Locomotive Development Committee of Bituminous Coal Research, Inc.[5]

A full-size coal-dust turbine locomotive is now well on its way to completion for test under railroad operating conditions. A byproduct of this research and development on coal utilization appears feasible in application of the coal-dust turbine to stationary use, particularly in areas of the country where water is not plentifully available. The coal-dust turbine requires little or no water in contrast with the conventional steam power-generating plant.

Carbonization and Gasification

Next to direct combustion of coal as a fuel, the production of coke, gas, and chemical products is the next largest field of utilization. In 1949, 80 pct of bituminous-coal production was burned for fuel purposes and 20 pct was used for carbonization and gasification.

At the Fourth World Power Conference in London in July 1950, it was evident from the papers and discussions that most nations that manufactured coke were concerned as to their reserves of coking coal. Many of them were conducting extensive research on making available their reserves of poorly coking coal by blending them with coals of better coking quality or by adding appropriate percentages of finely ground low-temperature coke, high-temperature coke breeze, anthracite fines, or pitch to the high-volatile coal charged into the ovens.

The United States also is facing the problem of extending its reserves of good coking coal by blending them with its much larger reserves of poorly coking coal to make a coke of adequate and usable quality; and of course this must be done before all of our high-quality coking coals are consumed. In most instances a better coke can be made by judicious blending of two or three different coals than from any one alone. This need is being recognized, and much attention is being given to research with experimental small and full-scale ovens, primarily for determining the physical properties of coke obtainable with various blends of coals and with different temperatures and rates of heating. This includes research on the expanding properties of the coal charge and the effect of various size consists of the charge. Such experiments by the Bureau of Mines and by industry were of immediate value when it became necessary to select coals from the Oklahoma-Arkansas field for supplying the wartime blast furnaces in Texas. Similar research on western coals was conducted for supplying the new blast furnaces in Utah and California.

During the war the general practice of blending low-volatile coal with high-volatile coal created a demand that was difficult to supply from available sources. This situation led to the use of anthracite fines at a number of plants to replace in part the usual proportion of low-volatile coal.[4] Such replacement gave satisfactory results at some of the plants as far as the physical properties of the coke were concerned, although it reduced the yield of byproducts. Since World War II some coke operators, especially those who were producing foundry coke, have continued using 2 to 8 pct anthracite fines to advantage.[6] Wartime research on blending coals was greatly facilitated by laboratory blending studies started before the war by several agencies.

The Bureau of Mines installed experimental slot-type ovens of about 400-lb capacity at its experiment stations at Pittsburgh, Pa., Denver, Colo., and Tuscaloosa, Ala. The Illinois Geological Survey likewise installed such an experimental oven and conducted extensive research in cooperation with industry on blending the higher oxygen Illinois coals with eastern bituminous coals and showed how this could be done with the production of suitable blast-furnace coke. The use of such experimental ovens and the Russell movable-wall oven at a number of commercial coke-oven plants has produced significant results in the improvement of coke quality by exploring the best possible blends of coals available. These investigations should lead to a considerable extension of our coking-coal reserves by including the lower ranks of poorly coking coal.

Closely related in importance to the washing and blending studies of coking coals in the last few years has been the Coke Evaluation Project sponsored jointly by the Iron and Steel Institute and the American Coke and Coal Chemicals Institute. Tests were conducted at various coke-oven plants with the aid of a portable testing laboratory installed on a truck. In this manner the same methods and equipment were used at the various plants, thus permitting comparisons heretofore impossible because of variations in sampling and testing. At the same time complete data on the analysis and size of the coal charged, the heat treatment of the charge, and the kind of ovens were obtained. While correlation of this work has not yet been com-

pleted, it is believed that significant practical results will be obtained.[6]

Research and development work on the Wisner process of low-temperature carbonization for the production of smokeless domestic fuel has resulted recently in the installation of a 1000-ton (coal)-a-day plant by the Disco Co. near Pittsburgh, Pa.[7] Progress also has been made in the use of low-temperature coke or char for improving the physical properties of metallurgical coke by blending some 15 to 20 pct of this low-volatile material with high-volatile coal at the plant of the Colorado Fuel & Iron Co. at Pueblo, Colo.[8] and at the Kaiser Co. plant at Fontana, Calif.[9]

During World War II increased demands for steel renewed interest in the possibilities of direct reduction of Minnesota iron ore with char or gas from North Dakota lignite. The Bureau of Mines began pilot-plant experiments on the carbonization and complete gasification of lignite and subbituminous coal.[10] It was found practicable to make a high-hydrogen gas that was especially suitable for the direct reduction of iron ore. A commercial-scale alloy-steel retort then was developed for further experimental operation to determine the best alloys for resisting corrosion and oxidation.[11] This development offers a means of using low-rank, noncaking coals for the production of high-hydrogen gas for synthetic ammonia, methanol, and other chemicals. Catalytic conversion of a part of this gas to methane would serve to produce high-Btu gas for pipeline transmission.

Another new development in low-temperature carbonization and to a greater extent in the complete gasification of coal has been the application of the "fluidized solids" technique[12] first employed in the catalytic cracking of petroleum to carbonization[13] and complete gasification of coal or lignite. In this process the bed of more or less finely divided coal becomes mobile and boils something like a liquid when a gas or vapor is passed through it. Such fluidization greatly promotes active contact between gases and solids, thus increasing rates of reaction and improving the temperature control of the process. This fluidization process works very well with lignite, subbituminous and noncaking coal but offers some difficulties with caking coal, which tends to soften and stick together. Thus far the best results have been obtained with noncaking materials; it is very promising in the production of carbon monoxide and hydrogen for synthetic liquid fuels, methanol, or synthetic ammonia.

Much research also is in progress on complete gasification processes where powdered coal is in suspension in a gaseous medium or in a fluidized bed. Oxygen and steam may be used as gasification mediums, and gasification at higher than atmospheric pressures promises greater economy than atmospheric pressure.

In England, the Gas Research Board has been conducting pilot-plant studies on the complete gasification of coal in fixed beds, using oxygen and steam under pressure and further raising the calorific value of the gas by catalytic conversion of part of the carbon monoxide and hydrogen to methane. The Board also is working on fluidized beds and on a process of hydrogenating the coal to produce a high-Btu methane-containing gas.[14]

In this country attention is being given to the production of a high-Btu gas from coal that would be suitable for supplementing natural gas when the supply becomes short or to furnish gas for peak loads. It is believed that such developments will become possible on the basis of work now in progress on the production of synthesis gas for liquid fuels.

The underground gasification experiments being conducted in the United States and abroad are necessarily of a long-range character. The results of the first and second experimental projects conducted by the Bureau of Mines in cooperation with the Alabama Power Co. show complete combustion of the coal bed as the fire progresses, and no difficulty has been experienced in maintaining it. However, much of the gas made is burned by short-circuiting of the air after the burned cavity becomes enlarged. This difficulty must be overcome to obtain a good producer gas. It might be possible to utilize the sensible heat, as well as the potential heat, in the gases thus generated by running the hot product gases into a gas turbine; as a matter of fact, this has been done at the Alabama experiment.

Synthetic Liquid Fuels

Finally in this review of recent coal research we come to the extensive program of research and development of the Bureau of Mines[15] and of industry in the production of synthetic liquid fuels. This work is bound to have significant economic results, not only in the provision of means for supplementing our supply of liquid fuels as our petroleum production declines below the constantly growing demand, but also for supplying chemical products from coal, and in opening up new fields of coal research that will have unforeseen commercial applications. Processes for the liquefaction of coal and for making synthetic liquid fuels were developed in Germany some 20 years ago. Both the Bergius-I.G. Farben. hydrogenation and the Fischer-Tropsch gas-synthesis processes were operated commercially in Germany before and during the war. These processes are now being improved and adapted to American conditions by Government and by industry. A 7000-bbl-a-day commercial plant for the production of gasoline, diesel oil, and chemicals from natural gas is beginning operation at Brownsville, Texas.

The Bureau of Mines is engaged in a comprehensive research and development program on oil from coal at Bruceton, near Pittsburgh, Pa., and on the production of synthesis gas from coal at Morgantown, W. Va. The gasification of lignite and subbituminous coal is being studied at Grand Forks, N. Dak., and at Denver, Colo. Research and development on oil from shale are being carried on at Laramie, Wyo., and large-scale development work by the Bureau is well-advanced on mining methods and retorting and refining processes at the oil shale deposit at Rifle, Colo.

Large-scale pilot-plant work on the production of oil from coal is proceeding at the Bureau's demonstration plant at Louisiana, Mo. A 200-bbl-a-day hydrogenation unit is in experimental operation, and a 50-bbl-a-day synthesis-gas or modified Fischer-Tropsch unit is nearing completion. Both of these pilot plants include new features and improvements developed by the Bureau's research groups and also are proceeding on the basis of research information obtained from German plants by American investigators following the close of hostilities. Test runs will be made on various ranks and types of coal from the different coal fields of

the United States. The oils obtained will be in adequate quantity for working out appropriate methods of refining and recovery of valuable by-products.

The Bureau of Mines demonstration mine at Rifle, Colo. has developed a highly mechanized method of mining a 70-ft-thick bed of shale that averages 30 gal of crude oil per ton. Operating costs in a recent test were about 30¢ a ton and overall costs are estimated at about 40¢ a ton. This low mining cost and a probably lower overall investment cost for mine and retorting plant than for coal-liquefaction plants favor oil-shale plants for being among the first synthetic liquid-fuel plants (aside from natural-gas plants) to compete with petroleum for supplying heating oils. At higher cost, shale oil may be converted to motor fuel by hydrogenation under pressure.

Interest in synthetic fuels production is growing. A number of oil and coal-processing companies are conducting research and development work on making oils from natural gas, coal, or oil shale. At present, cheap natural gas and oil shale seem to be the raw materials that will first approach the cost of natural petroleum products. However, further developments and rising prices of natural gas may bring coal and lignite into the picture earlier than is generally expected.

In addition to producing high-octane gasoline of good rich-mixture performance, the hydrogenation process can be made to yield a considerable proportion of benzene, toluene, xylene, phenol, and tar acids. These are now in short supply and are significant in view of the need of the synthetic rubber, plastics and chemical industries based on these materials. Defense requirements for these chemicals may lead to early construction of one or two coal-hydrogenation plants.

The Fischer-Tropsch or gas-synthesis process also may be regarded as an important new method of making useful chemicals from coal. In this case the chemical compounds belong to the aliphatic or methane series rather than the aromatic and napthenic series that characterize the products of the hydrogenation process. The Fischer-Tropsch by-products are alcohols, aldehydes and organic acids. Both processes will have significant economic impacts on the organic chemical industry and, of course, on the coal industry when the need arises to supplement materially our supply of petroleum.

Summary and Conclusions

In concluding this review of the economic significance of recent technologic research on solid fuels in the United States, it appears that the achievements of economic significance are greater than is popularly supposed. Although the production of synthetic liquid fuel and high-heating-value gas from coal has not yet arrived commercially, definite progress has been made in this direction. In addition to these potential developments in preparing for future needs, research in mining, preparation and utilization of coal has led to improved mechanical production and more efficient utilization.

The mechanical cutting, mobile loading and conveying of coal in the mine are continually being improved, and the continuous mechanical mining of coal without the use of explosives is in successful commercial operation. The preparation of coal has been improved by research on methods so that finer sizes of coal can be treated, with resulting greater reduction of impurities and improved recovery of coal. The efficiency and convenient use of solid fuels have been increased in residential stoves as well as in large industrial power plants. The powdered-coal combustion gas turbine gives promise for locomotive power and also for electric power in arid regions where condensing water is inadequate for steam plants. Recent research on coking blends of good and poorly coking coals are increasing our total reserves of coal for the production of metallurgical coke, and two pioneering, commercial, low-temperature carbonization plants are extracting chemical products from coal and lignite and are providing smokeless solid fuels for domestic use. Finally, it is believed that the extensive research now in progress on the production of synthesis gas from solid fuels will lead to significant future improvements in the utilization of coal in directions not now appreciated.

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Concentration of the Complex Copper-Lead-Cobalt-Nickel Ores of Southeast Missouri

by M. M. Fine, W. E. Brown, G. J. Vahrenkamp, and R. G. Knickerbocker

THE results of a research and development laboratory and pilot-plant mineral-dressing investigation by the Bureau of Mines of the complex copper-lead-cobalt-nickel ores of southeast Missouri are reported in this paper. This investigation, in cooperation with the National Lead Co., showed that separate concentrates of lead, copper, and cobalt-nickel could be made by fine grinding and flotation. An industrial plant built subsequently by the St. Louis Smelting and Refining Div. near Fredericktown, Madison County, Mo., produced such concentrates during the war years. Present commercial production at the mill is limited to lead and copper concentrates, but research to permit economic utilization of the cobalt and nickel values is continuing.

The complex sulphide deposits near Fredericktown in Madison County, Mo., have an operating history that dates back to the years preceding the Civil War. Perhaps these operations can best be summarized in terms of output which are given by Tyler,[1] "Previous to 1900, the Mine la Motte Co. shipped cobalt ore to Swansea and in 1903 produced 120,000 pounds of oxide in a Missouri plant. Another cobalt refinery erected in 1906 by the North America Lead Co. at Fredericktown, Mo., operated intermittently until 1910. In 1909 it produced 83,384 pounds of cobalt oxide, 328,403 pounds of nickel, 8,314 tons of nickel-cobalt concentrates, 600 tons of copper concentrates, and 1,353 tons of lead concentrates. This plant was purchased at a forced sale in 1915 by the Missouri Cobalt Co., which produced a certain amount of oxide in 1918 and in 1920 recovered 102,410 pounds of cobalt oxide and cobalt hydrate, valued at $262,810."

According to Buehler,[2] "The ore, which consists of a complex mixture of the sulphides of cobalt, nickel, copper, lead, and iron, occurs at the contact of the pre-Cambrian porphyry and the overlying Lamotte sandstone and Bonneterre dolomite." The source of most of the cobalt and nickel is siegenite, a member of the linnaetite series of minerals. Its composition is variable, and although the chemical formula may be given as $(CoNi)_3S_4$, it usually contains both iron and copper. The siegenite is characterized in this instance by an intimate association with chalcopyrite, and to a lesser extent with iron sulphides. Galena, on the other hand, while disseminated throughout the ore, is not closely bound to other constituents. Gangue is composed essentially of dolomite and quartz.

Petrographic examination showed that fair liberation of sulphides and gangue could be attained at −100 mesh. Complete liberation of micronsize inclusions, particularly of sulphides in each other would not have been possible at −400 mesh.

Beneficiation Studies

Many samples of the southeast Missouri ore were tested, but most of the work was confined to five samples of churn drill cuttings weighing 15 tons. The samples were reportedly representative of five sections of the deposit and were tested individually and as a composite. Only the results of the tests on the composite, which contained 1.28 pct lead, 2.03 pct copper, 1.06 pct nickel, 0.87 pct cobalt, 3.57 pct iron, 15.4 pct lime, and 23.9 pct silica, are presented in this report.

In view of the rather complex and intimate association in the mineralogical composition of the ore, flotation was the logical choice in the selection of a beneficiation process. Other mineral dressing unit operations were considered as an adjunct to flotation, but none were beneficial. Many tests were made on these samples to determine the flotation characteristics of the mineral siegenite. As a result of this work, it was noted the siegenite was intermediate in floatability between chalcopyrite and galena on one extreme and iron sulphides on the other. The difference in floatability between siegenite and the iron sulphides was not very great and, in general, the same reagents that depressed pyrite and marcasite would also, in slightly larger quantities, depress siegenite. This tendency for siegenite

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and pyrite to overlap made the concentration of the ores high in pyrite extremely difficult. The determining factor was actually the ratio of pyrite to siegenite in the sample. That is, with a low to medium ratio, fairly good recoveries were possible by flotation at good grades; in other cases, the reverse was true.

The most practical reagent suite included lime and cyanide as depressants for the rest of the sulphides while floating galena and chalcopyrite with an Aerofloat or lower xanthate. The siegenite was collected later by means of carefully regulated additions of a stronger promoter such as a higher xanthate. Judicious application of the promoter at that point was necessary to prevent undue flotation of the pyrite. Single cleaning of each concentrate with no additional reagents was the usual practice.

The results of a typical batch flotation test at a grind of −100 mesh on the composite sample are presented in Table I. The recovery of copper was excellent and that of the lead was fairly good in a concentrate containing 19.5 pct copper and 12.6 pct lead. Fair recoveries of both cobalt and nickel were made in another concentrate containing 14.5 pct cobalt and 16.3 pct nickel.

Pilot-Plant Operation

To confirm the results of the batch testing and provide the cooperating company with a large sample of the cobalt-nickel and copper-lead concentrates for further experimentation, pilot-plant flotation tests were made. The pilot-plant was operated 24 hr a day, except for minor interruptions for repairs and disposal of tailing.

In the pilot plant, the crushed ore was ground at an average rate of about 3.0 lb a min in a 19x36-in. ball mill in closed circuit with a 24-in. bowl classifier. As in the batch tests, lime and cyanide were added to the ball mill. The classifier overflow was laundered to a 12-in. conditioner, to which either Aerofloat 15 or 31 was added as a promoter for the copper and lead minerals. The pulp flowed by gravity to a bank of six Denver No. 5 flotation cells, where the chalcopyrite and galena were removed in bulk. The pulp leaving the copper-lead circuit was pumped to a similar bank of cells, where xanthate Z-8 and a frother were added and the siegenite was roughed off in the first three cells and cleaned once in the others. The final tailing was rejected in the cobalt-nickel circuit. The flotation pilot plant is shown in Fig. 1.

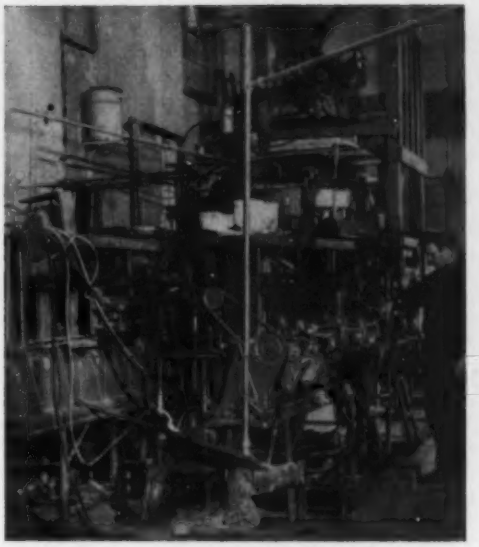

Fig. 1—Flotation pilot plant.

Results typical of a single shift during the pilot run are summarized in Table II. The recoveries of lead and copper were 87.1 pct and 81.6 pct in a concentrate analyzing 20.6 pct copper, 10.1 pct lead, 0.99 pct nickel, and 0.77 pct cobalt. This represented a material increase in the recovery of lead over that attained in the batch tests, but the recovery of copper was lower. At the time the pilot plant was in

Table I. Results of Batch Flotation Test

Metallurgical Data

Product	Weight, Pct	Analysis, Pct				Pct of Total			
		Pb	Cu	Ni	Co	Pb	Cu	Ni	Co
Copper-lead concentrate	7.7	12.6	19.5	1.8	1.4	74.1	92.6	14.0	12.8
Cobalt-nickel concentrate	4.1	2.0	0.30	16.3	14.5	6.3	0.8	67.7	70.8
Copper-lead cleaner tailing	1.5	3.0	1.0	1.2	0.70	3.4	0.9	1.8	1.2
Cobalt-nickel cleaner tailing	1.4	3.0	0.50	3.1	3.0	3.2	0.4	4.4	5.0
Rougher tailing	85.3	0.20	0.10	0.14	0.10	13.0	5.3	12.1	10.2
Composite	100.0	1.3	1.6	0.90	0.84	100.0	100.0	100.0	100.0

Operating Data

Lb per Ton of Ore

Reagent	Copper-lead Circuit				Cobalt-nickel Circuit		
	Ball Mill	Conditioner	Rougher	Cleaner	Conditioner	Rougher	Cleaner
Lime (burned)	3.0						
Sodium cyanide	0.20						
Aerofloat 15		0.12					
Xanthate Z-8					0.075		
Cresylic acid					0.12		
Time, min	20	5	5	4	5	5	4

Table II. Typical Results of Pilot-plant Testing

Metallurgical Data

Product	Weight, Pct	Analysis, Pct				Pct of Total			
		Pb	Cu	Ni	Co	Pb	Cu	Ni	Co
Copper-lead concentrates	7.9	10.1	20.6	0.99	0.77	87.1	81.6	7.7	8.9
Cobalt-nickel concentrates	5.1	1.3	0.5	14.4	9.3	7.2	14.1	71.9	68.6
Tailing	87.0	0.06	0.10	0.24	0.18	5.7	4.3	20.4	22.6
Composite	100.0	0.91	2.0	1.0	0.69	100.0	100.0	100.0	100.0

Reagents Consumption, Lb per Ton:

Lime (hydrated)	1.2
Sodium cyanide	0.23
Xanthate Z-8	0.14
Cresylic acid	0.19
Aerofloat 31	0.19

Table III. Results of Plant Operation

Product	Weight, Pct	Analysis, Pct					Pct of Total				
		Pb	Cu	Ni	Co	Fe	Pb	Cu	Ni	Co	Fe
Lead concentrate	2.89	75.97	2.66	0.21	0.16	3.26	90.61	6.95	1.53	1.51	1.15
Copper concentrate	3.39	2.81	22.76	2.45	1.86	36.72	3.81	67.68	19.91	19.70	10.85
Cobalt-nickel iron concentrate	4.56	1.50	2.77	4.28	3.26	35.74	2.82	11.46	48.35	48.10	20.15
Tailing	89.28	0.07	0.17	0.13	0.10	6.14	2.76	13.91	30.21	30.60	67.85
Mill feed	100.00	2.41	1.10	0.40	0.31	8.08	100.00	100.00	100.00	100.00	100.00

operation it was noted that chalcopyrite was not floating as readily as in the small tests. The latter had indicated that 8 min flotation time would be required for the copper-lead flotation. The six rougher cells in that circuit provided 8 min of contact time, and it was adequate for the galena, but rapid flotation of the chalcopyrite equal to that of the batch tests was not achieved. Flotation capacity was limited, and it was not possible to increase the number of cells to correct this situation. Other possible corrective measures, such as changes in the reagent combination, were investigated, but none were successful.

Considering other results of the pilot test, total recovery of nickel plus cobalt was greater than in batch tests, but the grade of concentrate was lower. The latter was due in part to the fact that chalcopyrite, which had not floated in the copper-lead circuit, reported in the cobalt-nickel concentrate.

Why chalcopyrite was more reluctant to float in the pilot plant than in the batch tests is difficult to explain. Differences in grind and soluble salt content may have contributed to the difference in behavior. In retrospect, it is probable the pilot results could have been improved by reducing the feed rate to provide additional contact time in the flotation circuit. While this is not an entirely satisfactory solution, such a move might have improved the copper recovery and both grade and recovery of the cobalt-nickel product.

Limitations in the amount of available flotation capacity also prevented inclusion of a copper-lead separation circuit in the pilot plant. However, batch tests made later on a sample of pilot-plant copper-lead concentrates showed that a separation could be effected either by 1—depressing galena with an alkali dichromate and floating the chalcopyrite, or 2—depressing the chalcopyrite with a cyanide and floating galena.

National Lead Co. Operations

Early in 1944, the National Lead Co. erected and placed in operation a 600-ton flotation mill near Fredericktown, Mo., the products of which were concentrates of lead, copper, and cobalt-nickel. The latter product, which was roasted prior to shipment, was reported to contain 19 pct nickel and 13 pct cobalt.[2] These products comprised the output of the mill until the end of World War II at which time production of high grade cobalt-nickel concentrates was suspended as a result of reduced demand for the two metals.

The Madison County mill has continued to operate but with emphasis on the production of metals other than cobalt and nickel. The analysis of recently milled ore, for instance, shows 2.41 pct lead, 1.10 pct copper, 0.40 pct nickel, 0.31 pct cobalt, and 8.08 pct iron.

Present practice in the mill calls for crushing and grinding to −65 mesh. A bulk flotation of all sulphides (other than part of the pyrite and marcasite) is effected at the outset, after which the application of a cyanide permits continued flotation of the galena only. The galena is cleaned and removed from the circuit. Remaining sulphides are thickened, reground to about −325 mesh and refloated. The latter operation effects a separation into a copper concentrate, which is sold, and a cobalt-nickel-iron reject, which is impounded on the premises. Results typical of 1950 operations are presented in Table III. Since those data were gathered, improved operations have resulted in a copper grade of 28.0 pct at substantially the same recovery noted in Table III.

A direct comparison between the plant data and the results of the Bureau of Mines pilot plant is not possible because of differences in procedure and analyses of the respective feeds. Certain similarities, however, are evident in both sets of data. Among these is the fact that galena is the most floatable constituent, so that an excellent recovery of lead is attained. A lesser recovery of copper is achieved in the copper concentrate, and much of the chalcopyrite that fails to report in that product is recovered later in the cobalt-nickel-iron concentrate.

Acknowledgment

Acknowledgment is made to E. S. Allen, former Mill Superintendent, St. Louis Smelting and Refining Div., National Lead Co., for supplying operating data of the Fredericktown, Mo., plant, and to Gloyd M. Wiles, Manager, Mining Dept., National Lead Co., for permission to publish those data.

Summary and Conclusions

The results of laboratory and pilot-plant investigations on the beneficiation of the complex copper-lead-cobalt-nickel ores showed that separate concentrates of lead, copper, and cobalt-nickel could be produced by fine grinding and flotation, a conclusion confirmed by the subsequent operation of the Fredericktown, Mo., plant of the National Lead Co.

Present output of the plant is limited to lead and copper concentrates as there has been no commercial production of cobalt and nickel since the end of World War II. The recent increase in demand for both metals for defense needs has instigated a considerable amount of research by government and private agencies into the utilization of southeast Missouri concentrates as a source of cobalt and nickel. The successful completion of that research probably will result in the resumption of commercial cobalt-nickel production in Missouri.

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Shallow Expressions of Silver Belt Ore Shoots Coeur d'Alene District, Idaho

by Robert E. Sorenson

EXPLORATION for deep-seated orebodies in the Silver Belt area of the Coeur d'Alene mining district is complicated by meager surface expressions of diagnostic criteria, lack of knowledge of the significance of specific alteration phenomena, and the great expense involved in the exploration for ore shoots, the tops of which often occur near sea level elevation or below and as much as 4000 ft or more below the surface. Except for the early studies of Ransome and Calkins in 1903 and 1904,[1] little geological work was done in the Coeur d'Alene district for many years, and it is only during the last 15 to 20 years that complete and careful geological mapping has been applied to most of the mines in the area. Much early information, which now would prove invaluable, is lost in hundreds of miles of caved and inaccessible mine openings not mapped by mining geologists. In more recent years mining geology has become a tool of greater use in the district, and some measurable progress is being made in the accumulation of observations that are adding gradually to the knowledge of ore deposits in the district.

The recognition of alteration phenomena and related features by Hoyt S. Gale[2] in 1935, followed by the work of Shenon and McConnel in 1936-37,[3] changed many of the concepts formerly held and opened the way for more critical study and mapping of alteration effects.

Mapping of these effects has been in progress for several years but no well-organized, careful, and complete laboratory study of the alteration has been made by mining companies or by government agencies. Recently, Thomas Mitcham of Columbia University has been occupied in the collection and study of specimens carefully selected from several producing mines in the Silver Belt as well as from several prospects exhibiting alteration effects. Mr. Mitcham and the writer have discussed some of the preliminary results of his investigations, which indicate that definite and interesting material is forthcoming from his studies. Work of this kind, aided by careful observation by district geologists, should advance the knowledge of the environment of Silver Belt ore shoots and establish additional criteria for recognizing meager shallow expressions of deep-lying orebodies.

Structural details in the Silver Belt area are extremely difficult to decipher on the surface because the area is almost completely covered by a deep mantle of surface debris and soil. A dense growth of small trees and buck brush adds to a geologist's difficulties. Often large areas reveal only scattered small outcrops with great intervening areas where the underlying formations must be deduced from small altered rock fragments. Some considerable success in obtaining surface information has come from bulldozer roads and cuts in selected areas. As this type of work receives more attention, knowledge of the surface expressions of formations, alterations, faulting, and veining is expanding and giving more reliable information to guide deeper development. Lack of diagnostic marker beds in the district contributes to a geologist's difficulties in determining fault displacements.

In the Silver Belt, known commercially important sulphide orebodies commonly are associated with siderite and quartz gangue. Some of the veins at shallow horizons above productive ore shoots are composed of quartz with light-colored carbonate minerals such as calcite, ferrocalcite, ferrodolomite, ankerite, and carbonates with variable amounts of manganese. The relation of these carbonates to commercial orebodies is a problem offering possibilities for research. Shallow exposures of veins composed of quartz and the light-colored carbonates, often with some associated barite, grade into quartz and siderite veins at deeper horizons. The vertical range of these carbonates has been partially established for some veins, but no reliable method has been devised for predicting where the change in a vein may take place. Careful observation and analysis of carbonates may make it possible to predict more closely where the change to siderite may be expected. In 1926 Shannon[4] pointed out some of the characteristics of the carbonate veins of the district and included a few chemical analyses.

Some of the Silver Belt ore shoots have small commercial outcrops, and very shallow development of some properties has led to the opening of small ore shoots.[5] Several small ore shoots developed at shallow depths have not been explored at deep horizons, and some important ore shoots with no commercially significant exposures at shallow horizons have been developed. The greatest problem of the mining geologist working in the Silver Belt area is to find the all-important link between the very meager shallow expressions of mineralization and the rich ore shoots that may be found below. To develop criteria for use in the recognition of the weak upper expression of ore shoots, the experience of past development programs must be relied upon heavily. The investment of more than a million dollars in the exploration for such ore shoots requires some reliable criteria if these ore shoots are to be found. Management needs some assurance that the risk involved is justified by well-developed and acceptable geological inference. The richness of some of the ore shoots found thus far has contributed greatly to the justification for a bold approach, but many negative results of blind exploration programs would lead eventually to extreme caution on the part of management. Fortunately, recent experiences of development programs have been quite successful. It is hoped that added knowledge of the environment of Silver Belt ore shoots will contribute greatly to the sureness of approach toward their development.

The Coeur d'Alene mining district is located in the panhandle of Idaho in Shoshone County. The population of the county is either employed in the

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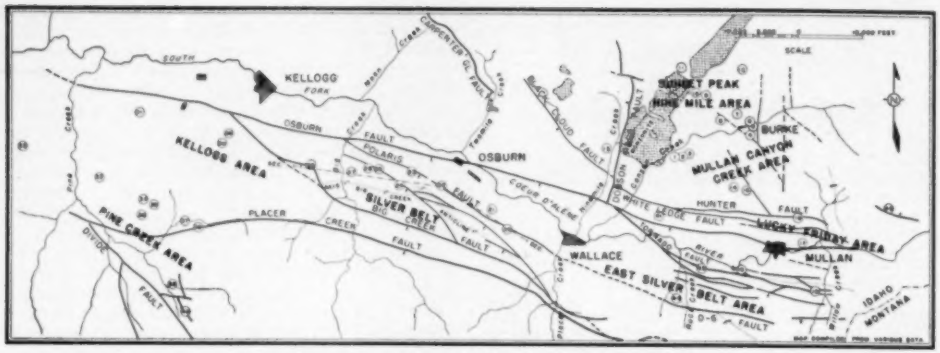


Fig. 1—Coeur d'Alene mining district showing mines and major faults.

1—Gem
2—Frisco
3—Black Bear
4—Hecla
5—Poorman
6—Tiger
7—Sherman
8—Standard Mammoth
9—Custer
10—Tamarack
11—Interstate
12—Hercules
13—Day Rock
14—Star
15—Morning
16—Gold Hunter
17—Lucky Friday
18—Atlas
19—Moe
20—Galena
21—Argentine
22—Coeur d'Alene Mines
23—Nellie
24—Silver Summit
25—Chester
26—Polaris
27—Sunshine
28 Crescent
29—Last Chance
30—Bunker Hill
31—Page
32—Hypotheek
33—Liberal King
34—Denver
35—Sidney
36—Pittsburg
37—Nevada Stewart
38—Highland Surprise
39—Douglas
40—Constitution
41—Golconda
42—Snowstorm
43—Gem State
44—Rock Creek

mining of lead, zinc, and silver or serving the requirements of those occupied in mining. The history of the district dates back to the first discovery of gold in the Murray district in 1879. The gold miners and prospectors from the Murray area roamed the Coeur d'Alene district in the search of more gold and in the early 80's discovered some of the lead-silver-zinc veins of the Mullan, Burke, and Kellogg areas. Minor production of the base metals began in the 80's, and annual production reached ten million dollars in 1900.[3] The district has continued to be a large producer of lead, zinc, and silver. Several years ago the district passed the billion dollar mark in the value of its output.

The distribution of the mines is shown on Fig. 1, which is compiled from several sources.[6] Much of the early production came from the Canyon Creek, Mullan, and Nine Mile areas northeast of Wallace and northwest of Mullan, and from the Kellogg area which contains the great Bunker Hill and Sullivan mine. The Pine Creek area located southwesterly from Kellogg gained more importance as the interest increased in zinc, the most important metal in Pine Creek.

Although the Silver Belt, shown in Fig. 2, contains some of the early lode locations of the Coeur d'Alene district, early production was restricted to very small near surface shoots which produced little or no profit to the early day miners. The Sunshine mine was worked in a small way until the late twenties, and persistent greater depth development of the ore shoots found near the surface, resulted in the development of one of the great silver mines of the world. Sunshine has paid more than 29 million dollars in dividends.

Success of the Sunshine venture brought about exploration of the Polaris mine adjacent to the Sunshine. The Coeur d'Alene Mines Corp. explored and mined a small ore shoot; Polaris Mining Co. through easterly workings of the Sunshine mine found the Rambo-Omega-Rotbart orebody containing more than 60 million oz of silver and 60 million lb of lead; and in 1948 Silver Summit Mining Co., assisted by financial help of Polaris Mining Co., found a deep-seated ore shoot on the 3000 level approximately 340 ft below sea level.[7] Since that time the vein was developed on 3200 and 3400 levels, and mining is proceeding at a rate of about 4000 tons per month. In the latter part of 1950, in a new deep shaft on the property of Vulcan Mining Co. on Lake Gulch just west of Wallace, the American Smelting and Refining Co. and Day Mines, Inc. began opening an extremely interesting orebody approximately at sea level elevation. The expansion of the Silver Belt proceeds easterly at an accelerated rate with new discoveries.

Geology

The principal rocks of the district are argillite, quartzite, and intermediate types comprising the Belt series of pre-Cambrian metamorphosed sediments widely distributed in northern Idaho, western Montana, eastern Washington, and southern British Columbia. In the Coeur d'Alene district this series consists of more than 20,000 ft of sediments of shallow-water origin that have been divided into:

1—The Prichard Formation, consisting of more than 12,000 ft of black argillite and argillaceous quartzite.[4]
2—The Burke Formation, approximately 1800 to 2400 ft thick, composed of gray to white quartzite and argillaceous quartzite.
3—The Revett Formation, 2100 to 3400 ft thick, comprising massive thick-bedded gray to white quartzite with some interbedded argillaceous quartzite.[4]
4—The St. Regis Formation, variously estimated as 1000 to more than 2000 ft thick and consisting of thin-bedded purplish-gray to purple argillite and quartzite.
5—The Wallace Formation, estimated by Shenon and McConnel to be 4500 to 6000 ft thick in the Silver Belt[4] composed of gray-black calcareous argillite and white to gray calcareous quartzite.
6—The Striped Peak Formation, consisting of 1500 ft or more of purplish, pink and green

quartzite, sandy quartzite and calcareous argillite, the youngest rock of the Belt series and not a host rock for any of the orebodies discovered thus far.

These sediments have been variously metamorphosed by dynamic processes with the development of abundant sericite and consolidation of the original rocks. The St. Regis and Wallace formations are the most prevalent formations seen on the surface in the Silver Belt and east to the Montana-Idaho state line.

The most abundant intrusive rock is the monzonite and syenite shown as small stocks and irregular masses in Fig. 1. Some associated dikes form protruding tongues in the sediments adjoining the monzonite. Contact metamorphic alteration of the sediments around the periphery of intrusives is common.[3]

Premineral diabase dikes and postmineral lamprophyre dikes, both commonly associated closely with large faults and with areas of mineralization, are widely distributed in the district.

Folding has greatly affected the rocks of the district. North of the Osburn fault the axes of folds generally trend northerly to northwesterly, and south of the fault the folds trend more nearly east-west. In the Silver Belt area the most prominent fold is the Big Creek anticline, shown in Figs. 1 and 2. It is a complex fold with a gently dipping south flank, an overturned axis, and a partially overturned north flank. Several minor folds occur on its steep north limb. In the East Silver Belt, see Fig. 2, another similar strongly developed and complex anticlinal structure has been mapped. There appears to be an intimate relationship between the stronger mineralized areas and the axis and the north flank of the Big Creek anticline. The prominent fold in the East Silver Belt area has similar relationships to much of the veining and sulphide mineralization that is known in this sparsely developed section of the district.

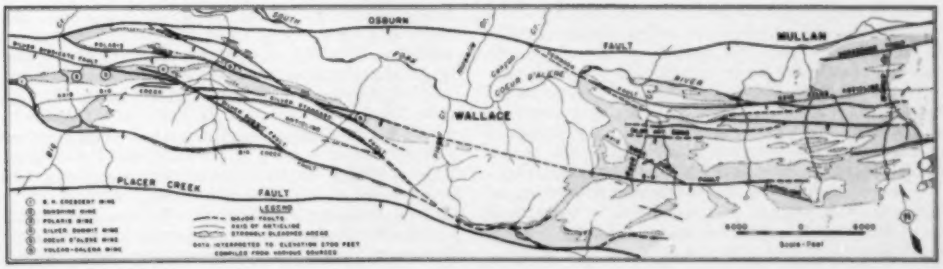
Faulting in the Coeur d'Alene district has been described by Ransome and Calkins,[1] Umpleby and Jones,[2] and Shenon and McConnel.[4] The great Osburn fault, which cuts an easterly-westerly course through the Coeur d'Alene district and which may be mapped for scores of miles east and west of the district, is known to most geologists as one of the world's great faults. It is a normal structure with a probable great horizontal component and has a southerly dip of 55° to 65°. Commonly, several hundred feet of crumpled rock, gouge, and breccia mark the structure, and it is expressed on the surface by a series of characteristic saddles on ridges crossed by the structure. On the north side of the Osburn fault other large fault structures have been described in the literature,[1,2] and a few of the major structures are shown in Fig. 1. In the area east of the monzonite intrusive and north of the Osburn fault, the predominating pattern is one of block faults.

South of the Osburn fault in the Silver Belt area some of the principal fault structures are shown in Figs. 1 and 2. One of these is the Placer Creek fault, a south-dipping normal fault located two to three miles south of the Osburn fault and trending roughly parallel to the latter across most of the district. Other important faults, all south-dipping, include the normal Polaris fault, the reverse Silver Summit or Silver Syndicate fault, the reverse Chester fault (vein), and the reverse Big Creek fault, all structures of persistence showing variable displacements generally measurable in hundreds to thousands of feet.[1,2] The above-mentioned structures, plus other linking faults, break the area into blocks of variable relative displacement. The tensional effects set up by differential movements on the major structures locally developed openings through which the mineralizing solutions were able to pass and in which many of the presently known veins were deposited by ascending solutions.

Although similar structural conditions have been mapped in the East Silver Belt by the U. S. Geological Survey[6] and by company geologists, the structure is not as completely known in this area because of meager underground development and poor exposures. Tentatively the D-6 fault has been correlated with the Polaris fault to the west and other strong faults, and associated vein-filled tensional fractures have been mapped in the eastern part of the area, see Fig. 2.

Alteration of the argillite and quartzite of the Silver Belt has been referred to in this paper and references were made to the original recognition of the "bleached" rocks by Gale[5] and by Shenon and McConnel.[4] This subject matter has been discussed by the author,[6,7] and Hobbs, Wallace, and Griggs mapped and described the bleaching in their preliminary report on the East Silver Belt area. As mentioned previously, careful investigation of the processes and chemistry involved has not been completed but such work is in progress. Also, Hobbs, Wallace, and Griggs[8] make a short reference to abundant chloritic alteration in the vicinity of the Atlas mine. This chloritization was mapped and described by the author in 1932 in connection with a study of the area for the Hecla Mining Co. Subsequent deeper exploration of the Atlas by the Hecla

Fig. 2—Silver Belt of the Coeur d'Alene mining district showing major faults and strongly bleached zones.



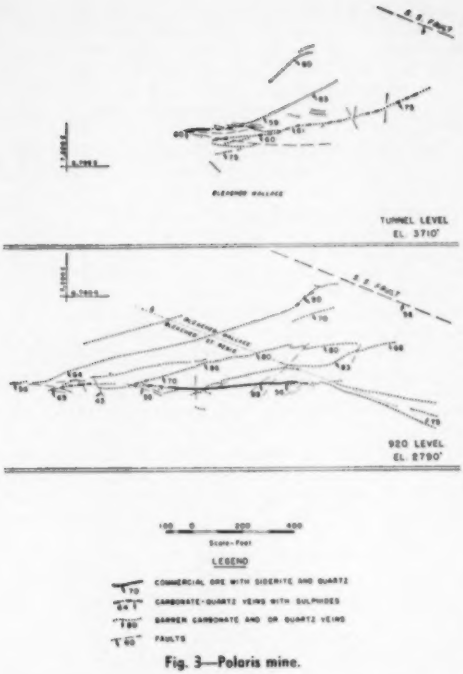


Fig. 3—Polaris mine.

Mining Co. revealed additional relationships between the chloritization and the more widespread bleaching. In 1941, in a private report to Hecla, P. J. Shenon pointed out the relationship of the chloritization and bleaching.

Chloritization in the vicinity of the Atlas mine is distributed in lens-like masses from a few feet to 500 ft wide and up to a mile long. Considerable chloritic quartzite is evident for about four miles westerly from the Atlas and more than a mile toward the east. The chloritized quartzite and argillite vary from pale green to intensely dark green depending on the amount of chlorite present. Whitish specks are disseminated through the rock in many areas giving the rock the appearance of a porphyritic texture. Weathering of the whitish particles gives them a lightly iron-stained coloration. In the thin section the rock is composed of rounded quartz grains showing secondary enlargement, sericite, carbonate, and chlorite. Chlorite and carbonate appear to be introduced substances, and with sericite they form the interstitial material between the quartz grains of the original sediment. The erratic distribution of the carbonate and chlorite, together with the fact that the chloritic zone crosscuts the quartzite on strike and dip, further sustains the viewpoint that the substances were introduced.

Deeper development of the Atlas area revealed that the chloritic rock, along with purplish sericitic quartzite of the St. Regis formation, was bleached by the later process, which developed the large strong bleached zones in the Silver Belt. The chloritic phase, then, was the early manifestation of hydrothermal alteration, probably a somewhat lower temperature phase as pointed out by Shenon in his Atlas report of 1941.

The bleaching process has been described in a general manner as it pertains to the Coeur d'Alene district but specific careful study remains to be done. Thus far no positive evidence has been developed to support the theory that an abundance of potash has been added to the original rocks, and the answer will come only from careful work. Sericite is generally present in large quantities both in unbleached and bleached rocks of the district. Megascopically, however, it appears that sericite is more abundant in the bleached rocks, and some of them might be classified properly as fine-grained sericitic schists.

Essentially the bleaching process resulted in the removal of the coloring matter in the original rock, thereby developing prevailing light colors varying from almost white through whitish-green to apple green. In some instances, especially in the finer-grained argillaceous rocks, original rock structures and textures are destroyed. Bedding may be unrecognizable or a pseudo-bedding may develop because of the prevailing direction of the bleaching that often follows shearing, fracture cleavage, or joints in the rock. Commonly, however, bleached bands follow bedding.

The purplish coloration of the St. Regis formation, largely caused by the presence of finely divided hematite, is entirely removed in thoroughly bleached areas, and it is the author's opinion that much of the iron of the abundant pyrite, disseminated in the bleached zones and often localized in certain areas within the bleached zones, had its source in the finely divided hematite dissolved from the rocks and carried upward by the bleaching medium.

The original coloring matter of the gray to black Wallace argillite is not definitely identified, but the bleaching process likewise removes all coloring matter from these rocks.

Although abundant disseminated carbonate, including ankerite, siderite, and possibly dolomite, are common in the bleached areas, sufficient work has not been done to clarify the relationship between the presence of the carbonates and the work of the bleaching medium. The carbonate may be more closely related to veining, which appears to succeed the bleaching in age.

Although the bleaching effects were noted first in the Silver Belt, and most carefully mapped there, the same alteration is prevalent in the Canyon Creek-Mullan area, the Kellogg area, and other sections of the Coeur d'Alene district and its extensions easterly and westerly. In the dark-colored Prichard argillite and quartzite bleaching appears to have effected less pronounced changes of the rock, and zones of bleaching in the Prichard formation are less prevalent than in the other formations.

Bleached zones tend to follow prominent structural trends, including crumpled flanks of folds, fault structures, shear zones, and other zones of disturbance. Locally, the more minor structures such as bedding, minor shearing, fracture cleavage, and jointing control the distribution of bleaching.

In the Silver Belt and its easterly extension the distribution of the zones and areas of bleaching are shown in Fig. 2. The most prominent and intense zone of bleaching follows a crescent-shaped course for several miles. The distribution shown on the map is necessarily somewhat diagrammatic because of imperfect exposures, but the prevailing trends of the zones have an easterly-westerly course through

the area, and the widths are extremely variable. The sources of the bleached pattern and much of the structure shown on the map include Shenon and McConnel's map of the Silver Belt,[4] Hobbs, Wallace, and Griggs' map of the East Silver Belt,[5] and company records and maps available to the writer. Although attempts have been made to differentiate between various intensities of bleaching, it appears probable that the bleaching process affects certain rocks quite differently than it does others. Intensity may be mapped within certain limits, but it is not definitely known what weight may be given to the evidence. Currently, the attempt is to make a differentiation of this kind with the hope that such observations will serve some purpose as knowledge expands.

Veining in the Silver Belt area appears to be more prolific within the bleached areas, but several veins are found in unbleached rocks. Although some commercially important mineralization is associated intimately with some of the major faults, for example, the Silver Syndicate, the Chester, and the Alhambra faults, the most important orebodies found thus far favor tensional fractures that have resulted from stresses set up by the differential movement on the larger structures. Following the bleaching, these tensional type fractures were opened by structural adjustment, and carbonate-quartz-pyrite veins filled these fractures. Subsequent adjustment reopened the veins for the entrance of the sulphides. Quartz and siderite accompanied the sulphides, and a late stage of quartz succeeded their deposition. Sequence of sulphide deposition in most of the veins studied appears to have been pyrite, arsenopyrite, sphalerite, chalcopyrite, freibergite, and galena. The position of chalcopyrite in the sequence is not shown clearly in all of the instances studied. It often appears earlier than the silver-rich tetrahedrite, but a contemporaneous and even a later deposition is often indicated in the polished surface.

Subsequent to the sulphide stage of mineralization, a late phase of chloritization developed minor chlorite on small faults, minor shears, and joints. Occasionally the mineral has a dusty appearance in minor openings, and in several instances it appears to be a halo mineral around ore shoots. This relationship might be expected if the mineral is the dying ebb of mineralization.

It has been suspected by most geological workers in the Coeur d'Alene district that the monzonite intrusives present in the Canyon Creek-Nine Mile area are merely small protuberances of a large batholith underlying most of the district. The widespread areas of alteration in the Canyon Creek-Mullan area testify to the presence of such an underlying source of the bleaching medium, and on this north side of the Osburn fault, zones of strong bleaching may be followed to the Montana line and into that state for tens of miles. Likewise south of the Osburn fault in the Silver Belt, East Silver Belt, and on into Montana toward the east, similar zones of alteration persist with unabated strength. Diabase and lamprophyre dikes appear most prolific in these same areas, the former preceding and the latter succeeding the period of greatest sulphide development. The distribution of these features is more than a coincidence. Strong, persistent, depth-reaching fault structures like the Osburn, Polaris, Big Creek, and Placer Creek faults with reoccurring structural adjustment opened the area and maintained openings through which the mineralizing medium was able

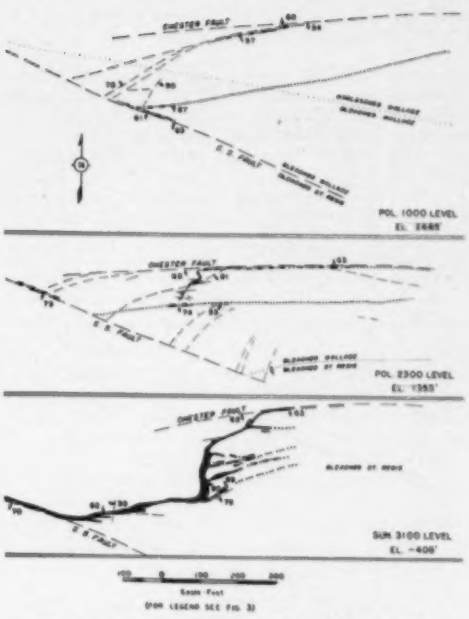


Fig. 4—Omega-Rotbart Veins, Sunshine and Polaris mines.

to pass toward the surface and produce the above results.

Although much evidence of alteration, faulting, and veining is obscured by an overabundance of debris, soil, dense brush, and timber, geologists are able to select zones of more prolific alteration on the surface. Evidence of veining often may be found, and inexpensive bulldozer work of recent years serves to clarify the situation and allows more careful structural mapping to be done.

Because exploration for Silver Belt ore shoots must reach to depths requiring a large amount of underground work and more than the usual amount of expense incurred in finding orebodies, geologists of the district have been groping for shallow evidences of ore shoots. The shallow expressions of some of the known orebodies have been so meager that only the most daring approach has been possible in the past, but deliberate and extremely careful observation, mapping, and research may serve to bridge the gap between a blind approach and a well-planned development program tied to the probable structural environment of the type of orebodies sought and closely related to factual material available to the careful observer.

Geologists must depend on the background of evidence resulting from previously successful exploration programs and take heed from negative criteria available in the study of unsuccessful ventures when seeking new and unknown orebodies. It is important that the approach to new developments include careful observation that may serve to enlarge the scope of the science and develop more complete evidence for direct application to the search for deep-lying, hidden ore shoots.

In the Silver Belt the structural environment differs in the several productive properties, but the general statement may be made that the ore shoots

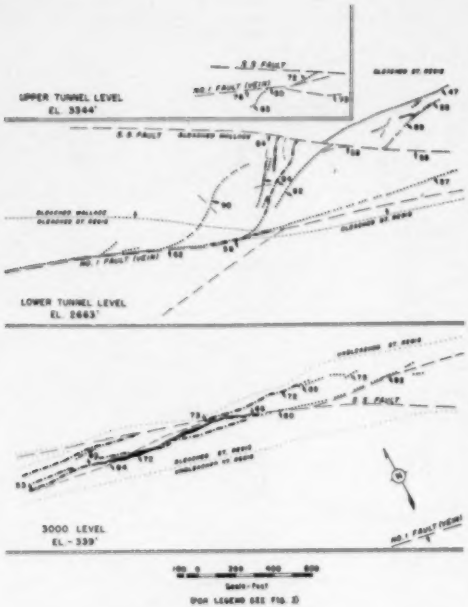


Fig. 5—Silver Summit mine.

have been found at depth below shallow expressions of strong structural conditions with associated zones of intense alteration and abundant veining. A study of fault structures may reveal a fracture pattern that should result in strong disturbance of a selected area. Within this area abundant veining by quartz, calcite, ankerite, barite, and/or siderite gives added evidence of structurally developed openings reaching downward toward the source of solutions and gases normally expected to carry ore minerals toward the surface. The degree of mineralization by the sulphides at shallow horizons in these veins is not a measure of the probable productiveness of deep-lying ore shoots, but the presence of these potential ore shoots is indicated variously by the shallow presence of some of the sulphides sought. The author believes that careful consideration of mapped areas of strong structural conditions, alteration, and veining will reveal sufficient evidence to allow careful projection of the features downward toward a potential locus of mineralization. The deeper development program should be directed toward this indicated locus, toward anticipated favorable wall rock conditions, and toward the zone within which siderite may be expected to be the prevailing gangue in contrast with the lighter-colored carbonates previously mentioned.

As a generalization, it may be said that many almost barren veins in the shaly rocks of the Wallace formation contain rich commercial ore shoots shortly after entering the more brittle friable quartzite of the underlying St. Regis formation. Examples of this are the Sunshine, Polaris, and Rambo-Omega-Rotbart areas in the Chester vein, and the Galena vein opened in the Vulcan shaft development. There are several other situations where this approach may have a good chance of success.

Although it is very often possible to predict the position of the top of more brittle bleached rocks with a fair degree of certainty, it is difficult to predetermine the zone within which other carbonates may give way to siderite, the most favorable gangue material known thus far.

The Polaris mine adjoins the Sunshine mine on the east, and the original claims covering the vein outcrops were among the earliest locations in the Silver Belt. Siderite float was explored by shallow pits, and minor silver-copper mineralization influenced the early day operators to drive the upper tunnel. Drifting on the vein structure was encouraged almost continuously by the presence of some sulphides, and near the westerly end of the tunnel a narrow streak of tetrahedrite in a fairly strong siderite vein was stoped for a length of about 90 ft and for 30 to 60 ft above the level. Winze exploration 70 ft below the level failed to find commercially significant ore, and the project lay dormant until the Hecla Mining Co. became interested in 1930. The situation on the tunnel level at that time is shown in the upper part of Fig. 3.

Although the approach to deeper development was influenced to a great extent by the requirements of shaft location, lack of knowledge of the environment of Silver Belt ore shoots and property situations, the Polaris orebody was discovered on the 920 level as shown in Fig. 3. A large amount of exploration was done on unproductive veins east and north of the ore shoot before commercial ore was found. The ore shoot was mined to a point above the 670 level, and subsequent exploration on deeper levels was successful in finding the dip extension.

If the initial objective of the crosscut from the bottom of the shaft had been the downward projection of the locus of veining and mineralization as it was exposed on the tunnel level, the crosscut would have found the orebody, and much of the other exploratory work would have been unnecessary.

Early in the Polaris development program the author made use of the system of vein contouring described by H. J. C. Conolly[5] in 1936. In the deeper exploration the trend lines so developed indicated the down-dip projections of important ore shoots, and this method applied to the adjoining Sunshine mine, in conjunction with the Polaris, also gives an excellent demonstration of the adaptability of the method. The Polaris veins are being mined on Sunshine's 2700 and 3100 levels, respectively 10 ft and 400 ft below sea level.

The Omega-Rotbart veins are located easterly from the main part of the Sunshine mine, on the north or footwall side of the Silver Syndicate fault, and on the hangingwall side of an expression of the Chester fault, see Fig. 4. In the development of the Polaris vein via the 1000 level, or Polaris lower tunnel level, the fault-vein relationships were found as illustrated. A strong structural environment, abundant veining, and minor amounts of the sulphides were well indicated on this level. Development of the projected locus of mineralization on the Polaris 2300 level gave further encouragement for the deeper development from the easterly end of the Sunshine mine on Sunshine 2700 level where bonanza silver-lead ore was opened. The 3100 level is shown in Fig. 4 where a length of almost 1000 ft of continuous high-grade silver and silver-lead ore was developed. This ore shoot has been opened through a vertical range of more than 1400 ft reach-

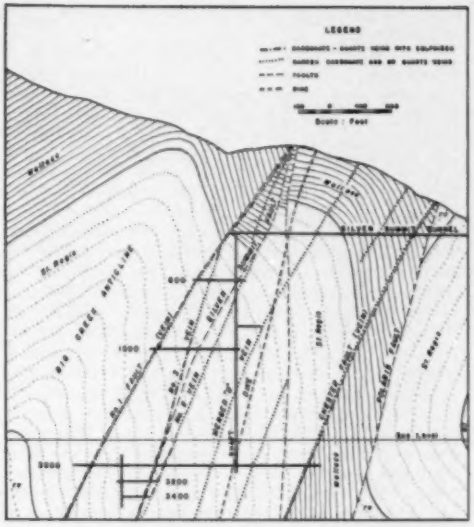


Fig. 6—Section through Silver Summit mine looking westerly.

ing from above the Sunshine 2300 level to the 3700 level, the latter level being about 1000 ft below sea level.

The Silver Summit mine, recently added to the list of producers of silver ore in the Silver Belt, has been described by the author in earlier papers.[6,7] It is located almost a mile easterly from the east end of the Rotbart area described above. On the upper tunnel level early day prospectors found small veins as shown on Fig. 5, and later exploration by Harry Pearson and associates on the lower tunnel level found the veins and fault structures shown on the center portion of Fig. 5. Some of the veins were entirely barren quartz or quartz and carbonate veins containing carbonate of light color and others contained some siderite. The No. 1 vein was largely siderite with minor amounts of tetrahedrite and pyrite, and in one locality the vein reached a width of almost 14 ft of solid siderite. A shaft was sunk in successive stages to the 600, 1200, and 1500 levels, and some work was done on the most southerly vein structure on 600 and 1500 levels without success. Polaris Mining Co. financed the development from the 1500 level to the 3000 level. On the new bottom level the direction of the south crosscut was determined to a great extent by the position of various development objectives planned for the level. The development program found the Silver Summit ore shoots as they are shown on Fig. 5 and partially described in a former paper.[7]

On the lower tunnel level the structural environment was strong, bleaching was pronounced, veining was prolific, and the sulphides sought were clearly in evidence in several of the veins. The down-dip projection of these structures, which contained evidence that they were tributary to the locus of mineralization, point directly toward the ore shoots found on the deeper levels.

Since the vein was opened on the 3000 level an offset winze was sunk, and the 3200 and 3400 levels opened the ore shoots. Mining is proceeding on all levels, and during 1950 net smelter returns totaled $1,251,173.

Fig. 6 shows some of the relationships of folding, faulting, and veining through the Silver Summit shaft.

Other mines in the Silver Belt, including the main Sunshine, the Coeur d'Alene mines, and the Galena or Vulcan, appear to exhibit the characteristics described in this paper. Several prospects including Silver Dollar (Lincoln), Nellie, Argentine, Rock Creek and possibly others appear to exhibit in varying degrees the above characteristics.

Although the principal objective of this paper is to point out some possible shallow expressions of Silver Belt ore shoots, the following features also have been observed to exert a local control over the location of ore shoots:

1—Promising veins where they cross folds or warps in the wall rock.

2—Warps in veins both on strike and dip (see contouring method references above).

3—Where veins approach prominent fault structures.

4—Where strong veins in unbleached or partially bleached rock enter zones of intense bleaching.

5—Where veins in argillaceous rocks enter more brittle quartzitic rocks.

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"Depletion" in Federal Income Taxation of Mines

by K. S. Benson

DEPLETION is a subject of vital importance to the mining industry. Yet, in spite of its importance, its significance is not generally understood. The purpose of this discussion is to clarify the main aspects of the subject from the viewpoint of a metal mine taxpayer.

To define the term depletion, it is necessary to distinguish among its various uses. In the economic or geological sense, depletion means the exhaustion of a natural resource. A mineral deposit is a wasting asset and once exhausted is nonrenewable. Millions of years were needed to produce an ore deposit, which may be consumed in a few years and which cannot be replaced except by the discovery of new sources of supply. The wasting asset feature of the mining industry has a vital bearing on the impact of the Federal Income Tax Law on this industry. This is recognized in the law by the various provisions dealing with the depletion allowance, and in this sense the term depletion has an income tax meaning.

Depletion from the tax viewpoint means the statutory deduction from gross income designed to permit the return to the taxpayer of the capital consumed in the production and sale of a natural resource. The mining enterprise realizes income on the extraction and sale of minerals and a portion of the income realized represents capital consumed. As the resource is exhausted, the mining enterprise approaches the end of its existence unless new sources of supply can be acquired. Depletion from the tax viewpoint is a creature of statute with limited meaning and application and, in essence, is a method for amortizing the value of the primary asset of a mining enterprise.

An example can best illustrate the significance of depletion from the tax viewpoint. Compare a manufacturing concern with a mining company. In computing taxable income of a manufacturing concern, consideraion is given to the cost of producing such income, the principal costs being capital investment for plant and equipment, labor, and raw materials going into the products produced. A mining enterprise, on the other hand, is faced with a different problem because its principal asset is the natural resource which it is producing. In computing its taxable income, consideration is given also to its capital investment for plant and equipment and the cost of labor; but in addition, recognition must be given to the fact that a portion of the proceeds realized on the sale of mineral represents capital. Without such recognition, the mining company would be taxed not on income but on capital and income, and Congress has never intended that capital be taxed as income.

Thus, when depletion allowable is referred to in the mining industry, it means the statutory deduction allowable in computing taxable income of a mining enterprise. For guidance the appropriate provisions of the Internal Revenue Code, Income Tax Regulations, and the judicial decisions interpreting and construing them must be examined. It is important to identify and distinguish three methods of determining the allowance for depletion: 1—Cost depletion, 2—Discovery depletion, and 3—Percentage depletion. The basic method is cost depletion and in addition some taxpayers may be entitled to use discovery depletion and other taxpayers may be entitled to use percentage depletion. Discovery depletion and percentage depletion, however, are mutually exclusive and if a taxpayer is entitled to percentage depletion, he is not entitled to discovery depletion. By statute, a metal mine taxpayer is entitled to use cost depletion or percentage depletion, whichever produces the highest deduction. Thus, discovery depletion is merely of academic interest to such taxpayers and to most others. Briefly and broadly speaking, these methods of determining depletion may be described as follows:

1—*Cost Depletion*: Under this method, the allowable deduction for depletion is based upon the cost of the particular deposit to the taxpayer, unless the deposit was owned prior to Mar. 1, 1913, in which case the taxpayer may use the fair market value of the deposit on that date or actual cost, whichever is higher. This method is sometimes described as *basis depletion* or *adjusted basis depletion*, but in this discussion it will be referred to as *cost depletion*.

2—*Discovery Depletion*: Under this method, the allowable deduction for depletion is based on the fair market value of the deposit at the date of discovery or within 30 days thereafter and was originally designed to take into account deposits discovered subsequent to Feb. 28, 1913.

3—*Percentage Depletion*: Under this method, the allowable deduction for depletion is based on a specified percentage of the income realized during the taxable year from a particular property.

As stated, the concept of depletion is based upon the exhaustion of a natural resource as distinguished, for example, from the concept of depreciation based on the exhaustion of property used in trade or business. From the tax viewpoint, depletion first became important in the administration of the Corporation Tax Act of 1909, which provided for an excise tax on net income. As soon as this act went into effect, mining taxpayers attempted to claim a deduction for depletion in computing net income although there was no specific mention of a deduction for depletion in the statute. The courts in these cases uniformly held that the statute did not permit an allowance for depletion in computing net income and also held that the provision permitting a reasonable allowance for depreciation did not include depletion. These early cases are quite significant because they establish the principle that the

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deduction for depletion is not a matter of right but of Congressional grace, and reference must be made to specific statutes to determine the scope of the depletion deduction.

As a result of the hardship to operators of mines, Congress in the first income tax law (the Revenue Act of 1913) provided for ". . . a reasonable allowance for the exhaustion, wear and tear of property arising out of its use or employment in the business, not to exceed, in the case of mines 5 pct of the gross value at the mine of the output for the year for which the computation is made, . . .". The word *depletion* first made its appearance in the 1916 Revenue Act, which provided for a reasonable allowance for depletion in the case of mines not to exceed the market value in the mine of the product thereof mined and sold during the year for which the return and computation are made. The 1916 Act limited the deduction for depletion to the recovery of cost, or in the case of deposits acquired prior to Mar. 1, 1913, to the fair market value as of that date. The principal change in the 1918 Revenue Act was the introduction for the first time of discovery depletion in the case of mines, oil, and gas wells discovered by the taxpayer on or after Mar. 1, 1913, with the depletion allowance based upon the fair market value of the property at the date of discovery or within 30 days thereafter.

Essentially two methods of computing depletion had developed, namely, cost and discovery depletion. During the ensuing years, it became evident that the administration of both cost depletion and discovery depletion was too complex and many inequities were unavoidable, so that the remedy seemed to be the adoption by Congress of a different, simpler and fairer method of calculating the allowance for depletion. In the 1926 Revenue Act, Congress, in the case of oil and gas wells, adopted percentage depletion so as to permit the deduction for depletion to be based upon a percentage of gross income derived from the properties, limited to 50 pct of the net income of the taxpayer from each property, and at the same time eliminated discovery depletion with respect to these items. In the 1932 Revenue Act, percentage depletion was extended to coal, metal mines and sulphur, and at the same time discovery depletion eliminated with respect to these items. Since that time, the benefits of percentage depletion have been extended to many other items.

This summarization, while not complete, points out the manner in which the methods of computing depletion have developed, and illustrates that once Congress recognized the concept of depletion for tax purposes the main problem was, and still is, the determination of the amount and method of computing the depletion deduction.

Sections 23(m) and 114(b) of the present Internal Revenue Code relate to the allowance for depletion and reference must be made to these sections as well as to the regulations issued by the Commissioner to determine the scope and application of the present depletion provisions. Section 23(m) provides, in computing net income, there shall be allowed as a deduction, "In the case of mines . . . a reasonable allowance for depletion and for depreciation of improvements, according to the peculiar conditions in each case; such reasonable allowance in all cases to be made under rules and regulations to be prescribed by the Commissioner, with the approval of the Secretary." Section 114(b) outlines the methods of calculating depletion and under this section of the Code a metal mine taxpayer may be entitled to a deduction for depletion based upon the cost method or upon the percentage method, whichever is higher.

The language of Section 23(m) clearly points out that depletion is not restricted by the form of legal entity seeking depletion. Thus it is allowable to individuals, corporations, partnerships, trusts, etc., assuming, of course, that the other requirements of the Code and regulations are met. All taxpayers, however, who seek a deduction for depletion must be the owner of an economic interest in a mineral deposit. Treasury Regulation 111, Section 29.23(m)-1 defines an economic interest as being possessed, ". . . in every case in which the taxpayer has acquired, by investment, any interest in mineral in place . . . and secures, by any form of legal relationship, income derived from the severance and sale of the mineral . . ., to which he must look for a return of his capital. But a person who has no capital investment in the mineral deposit . . . does not possess an economic interest merely because, through a contractual relation to the owner, he possesses a mere economic advantage derived from production." This requirement that a taxpayer be the owner of an economic interest has caused much litigation, and the definition set forth in the regulation developed over a period of many years.

In addition to determining whether a taxpayer is eligible for the depletion allowance, the economic interest test is important in determining the tax consequence of certain transactions. For example, a taxpayer may claim that he has sold his interest in a mineral deposit to obtain a capital gain, but if he has retained an economic interest in the mineral, the payments received are ordinary income subject to depletion. On the other hand, a taxpayer may claim a deduction for depletion only to find that he has made a *sale* and thus no deduction for depletion is allowable. The allowance of depletion and the benefit of the capital gain provisions are mutually exclusive.

The test of economic interest has been, and still is, difficult to apply in determining whether or not the taxpayer is entitled to a deduction for depletion. At one extreme, it is clear that the sole owner and operator of a mineral property is entitled to depletion because he, of all persons, clearly has an economic interest in mineral in place. At the other extreme, a person who sells his interest in a mineral is not entitled to depletion because he has converted his economic interest in mineral in place into another form of capital. In between these two extremes, there are a myriad of transactions which fall on one side or the other.

1—*Royalty Payments*: In the usual lessor-lessee relationship, a mineral property is leased by the owner to an operator. The lessor receives a royalty rate from the lessee, and the lessee, realizes income from the production and sale of the mineral. Both the lessor and lessee have an economic interest and both are entitled to depletion. The lessor is entitled to depletion on income represented by royalty payments received, and the lessee is entitled to depletion on income realized on the extraction and sale of the mineral. It is immaterial whether the royalty is payable in mineral, or in a sum of money per unit extracted, or as a percentage of gross profits, or as a percentage of net profits. It should be noted,

however, that when royalty is based upon a percentage of net profits some question may still be raised as to whether the lessor is entitled to depletion. For many years it was held by the courts that a share in the net profits from the development and operation of a mineral property does not entitle the holder of such an interest to a depletion allowance even though continued production is essential to the realization of such profits. In two recent cases involving oil leases (Kirby Petroleum Co. vs. Commissioner 326 U.S. 599 and Burton-Sutton Oil Co., Inc. vs. Commissioner 328 U.S. 25) the Supreme Court ruled that a lessor receiving a share of the net profits realized by the lessee from operations under a lease is entitled to depletion on such share of the net profits because this interest constitutes an *economic interest*. The rule of these decisions has been followed in other recent cases and it is probable that this rule will be applicable to other types of leases.

2—*Stock Interest:* A stock interest does not constitute an *economic interest* in mineral in place. Therefore, a stockholder of a mining company or an oil company receiving dividends is not entitled to depletion upon such dividends. However, in some instances if the company making the distribution does not have any earnings or profits but makes the distribution from reserves arising by reason of cost depletion, the dividend may be nontaxable as a return of capital. Likewise if a stockholder in a mining company or an oil company sells his stock under an arrangement whereby he is to share in the net profits from the development and operation of the property of the oil company or mining company, such taxpayer is not entitled to a depletion deduction against the payments received under this arrangement.

3—*Stripping Contracts:* Although it does not appear that any stripping contract cases have developed involving metal mines, the problem has arisen in the case of coal mines. The Commissioner has ruled that contractors who have undertaken to remove overburden and mine coal may, dependent upon their rights in respect of the properties involved, be entitled to the deduction for depletion as in the case of other mineral properties. The allowance is warranted only where under the agreement between the parties, the stripping contractor obtains a capital interest in the mineral in place and must look to severance and sale of the mineral for the return of capital consumed in the process. Thus, if the compensation of the contractor is, by the terms of the contract, to be derived solely from the sale of the coal, depletion is allowable. If, on the other hand, the compensation of the contractor is dependent entirely upon removal of the overburden and other services with no part of the compensation derived from the extraction and sale of the coal, the deduction for depletion is not allowable. In some cases, it may be necessary to split the income received by the contractor so that the income derived from the mining and sale of the coal would be subject to the depletion allowance.

4—*Cash Payments:* If a lease is sold for cash plus a royalty, the seller-lessor is entitled to depletion allowance on only that part of the income arising from the royalty payment. If, however, the cash payment is an advance royalty, and the presence of an overriding royalty usually makes the cash payment an advance royalty, depletion is allowable on not only the royalty income but on the cash payment income. In connection with advance royalty and minimum royalty, Treasury Regulation 111, Section 29.23 (m)-10 prescribes a rule which may seriously affect a lessor. For example, if a lessor receives advance royalty or minimum royalty under the terms of a lease prior to production, he is entitled to a depletion allowance on such income in the year of receipt in accordance with the terms of the aforementioned regulation but if the mineral rights granted expire, terminate or are abandoned before the mineral which has been paid for in advance has been mined, the grantor must report in the year of such expiration, termination or abandonment income equal to the depletion deductions of prior years, and such prior deductions are restored to his capital account.

In addition to meeting the requirement of economic interest, the metal mine taxpayer must qualify as an operator of a *metal mine*. In this connection both the terms *metal* and *mine* have technical meanings. If low grade chromite ore is mined and pressed into refractory brick, no depletion is allowable because the mineral is not being used for a metal purpose. If the mineral, after mining, is processed into chromium metal, depletion would be allowable. Thus it is evident that the so-called *use test* can cause many complications. As to the meaning of the term *mine*, the best illustrations of the problem appear in the so-called tailings dump and lean ore cases that are becoming increasingly more important.

Income may be derived from reworking a tailings dump or from working a low grade ore dump, and this in turn raises the question of whether a deduction for depletion is allowable against such income. In the cases involving this point, the decisions have generally turned on whether a tailings dump or a lean ore dump is a mine within the meaning of Section 23(m). In the Kohinoor Coal Co. case (171 F. (2d) 880 (CCA 3rd) it was held that the lessee of a culm or refuse bank, thrown aside by the owner-operator of a coal mine, was not entitled to percentage depletion, and this case followed the rule of Chicago Mines Co. vs. Commissioner (164 F. (2d) 785 (CCA 10th)) and Consolidated Chollar Gould & Savage Mining Co. (133 F. (2d) 440 (CCA 9th). In this latter case, the taxpayer extracted ore from tailings dumps composed of broken ore bearing rock taken from adjoining mines, and the court held that such extraction did not constitute operation of a mine and percentage depletions was not allowable. On the other hand, the Ninth Circuit Court of Appeals has held that a taxpayer is entitled to depletion on income derived from reworking a tailings dump previously created by him by processing ore from his mine (Commissioner vs. Kennedy Mining & Milling Co., 125 F. (2d) 399) and has also allowed depletion on income derived by a lessee of a mine from the treatment of tailings left by a previous operator (New Idria Quicksilver Mining Co. vs. Commissioner 144 F. (2d) 918). While attempts have been made to distinguish these various cases, in all probability the question will never be free from doubt until ruled upon by the United States Supreme Court or until clarified by Congress.

There are several methods of computing the depletion allowance, assuming a taxpayer is entitled to the deduction for depletion. As previously pointed out, in computing the allowance for depletion, a

metal mine taxpayer should make two calculations, namely, the depletion allowable by the cost method and depletion allowable by the percentage method because he is entitled to the greater deduction.

Cost Depletion: To determine the allowance for cost depletion in a particular year, the taxpayer must establish three factors: 1—The basis upon which the depletion allowance is to be computed, 2—The estimated total recoverable units of mineral in the property, 3—The number of units of mineral sold in the year. Expressed in another way, the taxpayer divides his adjusted basis for the property by the total remaining units of mineral in the property to obtain the depletion unit. Then he multiplies the depletion unit by the number of units of mineral mined and sold in the year in question.

There are many technical questions involved in the determination of the basis upon which depletion is to be allowed, and each taxpayer should read carefully the provisions of Section 113 of the Code, along with the pertinent Treasury Regulations and Court decisions. Simply stated, basis means a money value assigned to property for tax purposes, and in the case of cost depletion it is the money value assigned to a mineral property for the purpose of computing the depletion allowance. Normally this is cost unless the property was acquired prior to Mar. 1, 1913, in which case it is cost or the fair market value of the property as of that date, whichever is higher, properly adjusted in accordance with the provisions of Section 113. Once the adjusted basis has been obtained, it normally is the basis for the entire property, and for depletion purposes this must be further adjusted so as to eliminate any cost or value of the land for purposes other than mineral production, to eliminate any amounts recoverable through depreciation and from deductions other than depletion, and to eliminate the residual values of such property at the end of the operation. Once the basis for depletion has been determined, it remains the same during the life of the property except that it is reduced by depletion deductions allowed and increased by allowable capital additions. On this latter point, Regulation 111, Section 29.23 (m)-15 provides that any expenditures in excess of net receipts for minerals sold shall be charged to the capital account recoverable through depletion while the mine is in the development stage. A mine is considered to have passed from a development to a producing status when the major portion of the mineral production is obtained from workings other than those opened for the purpose of development; or when the principal activity of the mine becomes the production of developed ore rather than the development of additional ore for mining. Thus, for example, in an open pit iron ore mine, the stripping cost prior to the time the mine becomes a producing mine is capitalized and recoverable through depletion, and the amount expended for this pre-production development would be an allowable capital addition to the basis for the calculation of cost depletion. After the mine reaches the producing stage, any stripping costs would be capitalized and deducted ratably against the production benefitted. Such deductions would be in addition to the allowance for depletion. On the other hand, whether in the pre-development or post-development stage, expenditures for plant and equipment and for replacements, not including expenditures for maintenance and ordinary and necessary repairs, shall ordinarily be charged to the capital account recoverable through depreciation.

After determining the basis for depletion, the next step is to determine the number of total recoverable units of the mineral in the deposit in the year in question. This involves an estimate on the basis of reasonably known facts at the time the estimate is made. The estimate is to be in accordance with methods current in the industry and the problem is primarily an engineering one. In the event either the Commissioner or the taxpayer, as a result of operations or development work, determines that the total recoverable mineral units are either greater or less than the prior estimate, a revision thereof is made and the revised estimate is used in determining the depletion unit.

Once the basis and total estimated units of mineral have been determined the depletion unit can be arrived at, and this unit is then multiplied by the units of mineral mined and sold within the taxable year. A simple illustration will point out the mechanics of computing cost depletion, although in practice most computations are not quite as simple. It may be assumed that a taxpayer purchases the fee of a property for the sum of $480,000 and that this property has no value except for the mineral contained therein. The basis for the purpose of computing cost depletion will be the purchase price of $480,000. If pre-production development expenditures total $120,000, this amount is an allowable capital addition and will increase the basis to $600,000. Assuming that the property contains an estimated 2,000,000 tons of recoverable iron ore, the depletion unit will be 30¢ per ton and on the production and sale of 50,000 tons, the cost depletion allowable would be $15,000 for that year. In the following year, $15,000 would be subtracted from the original basis, leaving a remaining basis of $585,000. If the total recoverable units of mineral remain unchanged (except for the subtraction of prior year's production sold), the depletion unit will continue to be 30¢ per ton until the total basis is recovered. In the event a revision is made of the total estimated units of mineral, the depletion unit will be either larger or smaller depending upon the revised estimate, but in no event can more than the remaining basis of $585,000 be recovered by cost depletion, or an overall total of $600,000 on the facts assumed.

Having calculated the allowance for cost depletion, the taxpayer should next compute the percentage depletion allowable.

Percentage Depletion: In the case of metal mines, the allowance for percentage depletion is 15 pct of the gross income from the property during the taxable year, excluding from such gross income an amount equal to any rents or royalties paid or incurred by the taxpayer in respect to the property but such allowance cannot exceed 50 pct of the net income of the taxpayer (computed without allowance for depletion) from the property. Thus, there are two limitations in the calculation of the percentage depletion allowance, and in some instances the allowance will be determined by the 50 pct of net income limitation, and in other instances the 15 pct of gross income limitation will govern. In view of these limitations, there has been much litigation because the Commissioner has attempted to minimize as much as possible *gross income* and *net income* in

order to reduce the allowance. Most problems involving the calculation of percentage depletion center about the meaning of *gross income, net income* and *property*.

Gross income from the property in the case of a crude mineral product other than oil and gas is defined to mean the gross income from mining. The term *mining* includes not only the extraction of the ores or minerals from the ground, but also the ordinary treatment processes normally applied by mine owners or operators to obtain the commercially marketable mineral product or products and so much of the transportation of ores or minerals (whether or not by common carrier) from the point of extraction from the ground to the plants or mills in which the ordinary treatment processes are applied thereto as is not in excess of 50 miles. If the transportation to the plants or mills exceeds 50 miles, the Commissioner must approve the excess transportation if it is to be included in the definition of gross income from the property. In the case of iron ore, the ordinary treatment processes include sorting, concentrating and sintering to bring to shipping grade and form and loading for shipment. If the taxpayer sells his mineral product in the immediate vicinity of the mine, gross income would be the amount for which the product was sold. If, however, the product is transported or processed other than for ordinary treatment processes, gross income would be the representative market or field price without such transportation and processing. In the case of iron ore, for example, the gross income from the property would be the f.o.b. mine value realized by the taxpayer on shipments less any rents or royalties paid or incurred with respect to the property.

Net income of the taxpayer (computed without allowance for depletion) from the property means the gross income from the property less the allowable deductions attributable to the mineral property upon which the depletion is claimed and the allowable deductions attributable to ordinary treatment processes insofar as they relate to the product of such property, including overhead and operating expenses, development costs properly charged to expense, depreciation, taxes, losses sustained, etc. but excluding any allowance for depletion. Deductions not directly attributable to a particular property or process are to be fairly allocated. The net effect of these requirements is to require in the computation of net income of the taxpayer from the property a deduction for almost every item which would be deductible in computing net taxable income from the property except depletion. For example, interest on borrowed money and amounts paid in settlement of silicosis claims are deductible but contributions to charity are not required to be deducted if they are not attributable directly to the mineral property.

Property is defined as the interest owned by the taxpayer in any mineral property, but in the event the taxpayer has interest in separate mineral properties, each interest is a separate property. Where two or more mineral properties are included in a single tract or parcel of land, the taxpayer's interest may be considered a single property, provided such treatment is consistently followed. This definition has caused confusion because one mine may involve two leases or may involve a combination of a fee interest and a lease interest; and for the purpose of percentage depletion, the Commissioner may require these interests to be treated as separate properties, causing difficult problems of allocation.

To illustrate the application of percentage depletion, the example in the discussion of cost depletion may be used. In that example the taxpayer produced and sold 50,000 tons of iron ore with, let it be assumed, an f.o.b. mine value of $5 per ton. No royalty payments are involved because the taxpayer owns the fee of the land and, therefore, his gross income from the property would be $250,000 and 15 pct of the gross income amounts to $37,500. If it is assumed that the net income of the taxpayer from the property, without allowance for depletion, amounts to $1 per ton, 50 pct of the net income on 50,000 tons would amount to $25,000 and the percentage depletion allowable would thus be governed by 50 pct of the net income and would be in the amount of $25,000. In this particular example, the excess of percentage depletion over cost depletion amounts to $10,000. The taxpayer would be entitled to a total depletion deduction of $25,000, and he would adjust his basis for the property by this amount, i.e. it would be reduced to $575,000 for the purpose of calculating cost depletion in the next year. As soon as the basis is fully recovered, the taxpayer will no longer be entitled to cost depletion but may still obtain percentage depletion.

This discussion has touched in a broad way some of the problems involving depletion. In using the term depletion, its meaning from an economic and geological viewpoint and its meaning from a Federal Income Tax viewpoint must be distinguished. Depletion from the tax viewpoint refers to a statutory deduction allowable in computing the taxable income of a mining enterprise. Every Revenue Act since 1913 has contained provisions relating to the amount and method of calculating the allowance for depletion. A metal mine taxpayer who otherwise meets the eligibility requirements is entitled to an allowance for depletion computed by the cost method or by the percentage method, whichever is higher. The determination of the depletion deduction by these methods is largely a mechanical process once the basic factors are established.

The mining industry differs from other industries because the mineral producer is really engaged in two interrelated activities. One activity involves the rendition of the services of mining and processing of minerals to produce a marketable product, and, in this respect, the mining industry is comparable to many other industries. The second activity, however, distinguishes the mining industry because it involves the sale of the mineral producer's supply of mineral. This supply of mineral is the basic capital asset of any mining enterprise, and the production and sale of the mineral ultimately involves the liquidation of the enterprise unless new deposits are discovered and developed. The discovery of new deposits in turn involves the expenditure of large sums of money for exploration, and it is well known that for every successful exploration there are many, many failures. The depletion provisions of the Code are intended to eliminate what would otherwise be an inequity because they recognize that capital should not be taxed as income. Also, these provisions, while in need of some changes to encourage and accelerate exploration and development, do assist in stimulating new risk capital to enter into the mining field and provide a method whereby existing mining enterprises may set aside funds for further exploration.

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aime NEWS

Morgantown Scene of Fall Nonmetallics Meeting

Plans for the Morgantown, W. Va., meeting of the Industrial Minerals Division to be held Sept. 13 to 15 are rapidly taking form. The session for the first day will be devoted to papers of local interest and the local group at Morgantown has arranged for seven papers to be given the morning of the 13th. Four and possibly five papers have been tentatively scheduled for the one-day session on the 14th, which will be devoted to industrial minerals as chemical raw materials. Three papers are on sulphur, one on industrial raw materials in general and one on lithium.

Those wishing to attend are requested to make hotel reservations directly with the Hotel Morgan at least one week in advance. Rates are: single bed, $3.75 to $4.00; double bed, $6.00 to $6.50; and twin beds, $7.00 to $9.00.

MED Statistics Committee Formed

The Mineral Economics Div. has formed a Statistics Committee and Charles W. Merrill, U. S. Dept. of the Interior, Bureau of Mines, Washington, is serving as Chairman. Olaf P. Jenkins, chief, California Div. of Mines, and A. J. Martin, supervising engineer, Economics Div., Bureau of Mines, Denver, have also accepted to serve on the Committee.

Oregon Section Prize Paper Awards

At a recent meeting of the Oregon Section, awards were presented to students who won the Oregon Section Annual Student Prize Paper Award Contest. First place went to Joseph D. Meyers for his paper entitled, "Compilation of Data on the Geochemical Interpretation of the Dissolved Mineral Content of Natural Waters." Second place was a tie between Rodney K. Williams, whose paper was entitled, "Stockpiling," and E. Allen Merewether for his paper "Uranium Bearing Minerals and Their Detection."

Coal Division Meets at Roanoke

The annual joint meeting of the Coal Division, AIME with the fuel section of the ASME will take place at the Hotel Roanoke, Roanoke, Va., Oct. 10 and 11. At this meeting it is usual to discuss developments in fuel utilization as well as other pertinent subjects such as resources, markets, preparation, and coal quality and grading problems. The program will be published in the September issue but Program Chairman Orville Lyons reports that an excellent selection of papers is developing. Regular attenders of this meeting are familiar with the pleasant mixture of business and pleasure which prevails at the annual Fuels Conference. A banquet, luncheon, dance, golf, and other sports are part of the arrangements. Hotel reservations should be made directly with the Hotel Roanoke.

Divisions Nominate 1952 Officers

Nominations for 1952 officers of the various divisions of the Institute are as follows:

Institute of Metals Division: *Chairman,* Walter A. Dean; *Sr. Vice-Chairman,* Morris Cohen; *Vice-Chairman,* Jack Scaff; *Secretary,* Ernest Kirkendall. *Executive Committee:* (3 years), George P. Halliwell, Oscar T. Marzke, W. E. Mahin.

Petroleum Division: *Chairman,* Paul R. Turnbull; *Vice-Chairman,* John R. McMillan; *Vice-Chairman,* Morris Muskat. *Executive Committee:* (3 years), E. N. Van Duzee, G. L. Yates.

Iron and Steel Division: *Chairman,* K. C. McCutcheon; *Vice-Chairmen,* J. B. Austin, E. K. Miller, T. J. McLoughlin. *Executive Committee:* (3 years), Walter Carroll, H. M. Griffith, J. S. Marsh.

Coal Division: *Chairman,* A. Lee Barrett; *Chairman-Elect,* Ralph E. Kirk; *Secretary-Treasurer,* David R. Mitchell. *Executive Committee:* (3 years), Frank W. Earnest, G. Ralph Spindler, Elmer R. Kaiser.

Mineral Industry Education Division: *Chairman,* Harry H. Power; *Vice-Chairman,* J. R. Van Pelt. *Executive Committee:* (3 years), C. J. Christensen; (Univ. of Utah); C. S. Crouse, (Univ. of Kentucky); E. M. Thomas, (Texas Western College). *Past Chairman,* Allison Butts.

Industrial Minerals Division: *Chairman,* Ian Campbell; *Eastern Vice-Chairman,* R. C. Stephenson; *Southeastern Vice-Chairman,* Allen Cole; *Western Vice-Chairman,* G. H. Waterman; *Rocky Mountain Vice-Chairman,* David Hale, Jr.; *Canadian Vice-Chairman,* M. F. Goudge; *Secretary-Treasurer,* James Norton. *Executive Committee:* (3 years), William Holland, Harold Bannerman, G. W. Josephson. To replace Ian Campbell on Exec. Comm. to February 1953, R. M. Foose.

Minerals Beneficiation Division: *Chairman,* E. H. Crabtree, Jr.; *Associate Chairman,* Donald W. Scott; *Regional Vice-Chairman,* S. D. Michaelson; *Regional Vice-Chairman,* Will Mitchell, Jr.; *Secretary-Treasurer,* William Stephenson.

Extractive Metallurgy Division: *Chairman,* T. D. Jones (automatic); *Chairman-Elect,* R. R. McNaughton; *Secretary,* Ernest Kirkendall. *Executive Committee:* (3 years), J. C. Kinnear, Jr., John D. Sullivan.

Mineral Economics Division: *Chairman,* Evan Just; *Vice-Chairmen,* Granville Borden, J. H. Richardson, S. H. Alliston; *Secretary-Treasurer,* Allan Matthews. *Executive Committee:* R. D. Parks, M. D. Harbaugh, Gilbert H. Cady. To replace Evan Just on Exec. Comm., S. G. Lasky.

Haider and Fletcher Head 1952 AIME Nominations Slate

Clayton G. Ball, Chairman of the Nominating Committee, has announced nominations for President, President-elect, Vice-Presidents, and Directors for 1952. As provided in Art. IX, Sec. 2, of the bylaws, 25 members or associate members may sign and transmit to the Secretary's office prior to Sept. 1 "any complete or partial ticket of nominees," should they wish other candidates to be considered.

In such instance, a letter ballot will be forwarded to all members in good standing in the United States, Canada, and Mexico, tabulating both the official ballot and any supplementary nominations. If no supplementary nominations are thus received, no letter ballot will be printed, and nominees on the official ballot shall be declared duly elected at the meeting of the Board of Directors or the Executive Committee in November.

M. L. HAIDER
For President, 1952

ANDREW FLETCHER
For President-Elect

For Vice-Presidents

O. B. J. FRASER

J. B. MORROW

For President

Michael Lawrence Haider was born in Mandan, N. Dak. in 1904. He attended the University of Southern California and Stanford University from which he graduated in 1927 with a B.A. degree in chemistry. After graduation, he was employed by the Pacific Portland Cement Co. and later entered the petroleum industry with the Pan-American Petroleum Co. from which he was transferred to the Richfield Oil Co. In 1929, he became affiliated with the Carter Oil Co. Mr. Haider joined the Standard Oil Development Co. in 1938 as manager of the production engineering and research dept. In 1945 he was transferred to the producing dept. of Jersey Standard Oil Co. in the position of executive assistant and was responsible for various foreign operating affiliates. In 1946 he was transferred to Imperial Oil Ltd., Canadian affiliate, with headquarters in Toronto, his current residence. In 1948 Mr. Haider was elected to the board of directors of Imperial and in 1950 became a vice-president. He is currently responsible for the purchasing and transportation departments. Mr. Haider became a member of the Board of Directors of AIME this year. For several years he served as Chairman of the Publications Committee of the Petroleum Div., was Chairman of that Division in 1945, and has been active on numerous committees of the Institute.

For President-Elect

Andrew Fletcher, president of St. Joseph Lead Co., has been nominated for the Presidency of AIME in 1953. Mr. Fletcher, who was born in 1895 in New York City, was educated at Hill School and the Sheffield Scientific School, Yale University, where he received a Ph. B. in mechanical engineering. In 1949 the University of Missouri conferred upon him an honorary degree of Doctor of Engineering. In addition to being president of St. Joseph Lead Co., he is also president of Mine La Motte Corp., and Bonne Terre Farming & Cattle Co. He is vice-president of Missouri-Illinois R. R. Co. and director of the American-Hawaiian Steamship Co. He has been on the Board of AIME for many years, and has been Treasurer since 1944.

For Vice-Presidents

Oliver B. J. Fraser, assistant manager of the development and research div. of International Nickel Co., New York, has been an AIME member and a highly active one, since 1918. He is a past Chairman of the New York Section and has served on the following AIME committees: Ways and Means (1945-46); MINING AND METALLURGY (as chairman); President's Advisory (1947-48); Nominations for 1951 AIME Officers (as chairman); Auxiliary Publications Committee, Institute of Metals Div. (as chairman), and on the Program Committee, IMD. He is the author of many outstanding publications and the AIME has published many of his technical papers. Mr. Fraser was born at Brockville, Ont., in 1895, and received the degree of B.Sc. at Queen's University.

James Bain Morrow, vice-president, retired, of Pittsburgh Consolidated Coal Co., was born in Halifax, Nova Scotia in 1886 and studied mining engineering at Dalhousie University. No better summary of Mr. Morrow's qualifications could be given than to quote from the citation read on presentation of the Erskine Ramsay Gold Medal at the AIME Annual Meeting in St. Louis last February: "As an engineer and scientist, Mr. Morrow has served the coal mining industry with distinction. As an executive, he has invariably presided with tact, judgment, and success. . . . In his active life, he has always found time to devote to young engineers, acting as an inspiration to them, and thereby enriching the industry with young blood." He has figured prominently on many committees of the AIME; and as Chairman, Vice-Chairman, and a member of the Executive Committee of the Coal Div.,

C. H. BENEDICT

R. B. CAPLES

T. B. COUNSELMAN

T. L. JOSEPH

C. E. REISTLE, JR.

he has taken a leading part in its activities. Many of his technical papers on the cleaning, sampling, and preparation of coal have been published by the Institute. In 1944 he received the Percy Nicholls Award.

For Directors

C. Harry Benedict has been nominated Director of AIME for a three-year term beginning February 1952. He previously served as Director from 1945 to 1950 and as Vice-President from 1948 to 1950. Mr. Benedict was born at Pittsburgh in 1876 and graduated from Cornell University in 1897. Immediately after graduation he became affiliated with Calumet & Hecla Consolidated Copper Co. He retired from active duty with this company in 1948. So much has been written about the famous ammonia leaching process, which Mr. Benedict developed, for recovery of copper from waste sand (tailing), that it is unnecessary to repeat an account of this achievement. Although Mr. Benedict has retired from "active" services with his company, he still continues his activities on behalf of the Institute and various other organizations, and is also writing a history of the Calumet & Hecla Consolidated Copper Co., which will be published late this year.

Russell B. Caples has been nominated as Director of AIME for the term 1952 to 1955. He was born in Glasgow, Mo. in 1888 and graduated from the Missouri School of Mines in 1910, where he received an honorary degree of Doctor of Engineering in 1948. Mr. Caples started his professional career with the Federal Mining & Smelting Co. in the Coeur d'Alene district of Idaho and shortly thereafter entered the employ of the Anaconda Copper Mining Co. He was first employed in the testing dept. of the Anaconda Reduction Works, working in collaboration with Messrs. Frederick Laist, F. F. Frick, and James O. Elton in the development of the electrolytic zinc process during 1914 to 1916 as well as the basic process for the Anaconda phosphate plant. In 1918 he became superintendent of the Great Falls, Mont., plant and was made manager in 1941. He has served on various committees of the Extractive Metallurgy Div. of the Institute, including the Executive Committee and its Committees on Lead and Zinc, and Pyrometallurgy. He is also a member of the Advisory Committee on Zinc of the Defense Minerals Administration.

Theodore Benton Counselman has been nominated Director of AIME for a three-year term beginning February 1952. He was born in New York in 1889, and graduated from Columbia University with the degree of engineer of mines. After a short apprenticeship with what later became Texas Gulf Sulphur, and with Inspiration, he got into ore dressing under the late John M. Callow. He followed this star to Greene Cananea, back to Arizona Copper Co. in Morenci, to Miami, and then went with D. C. Jackling on the first of the taconite ventures, the Mesabi Iron Co. After eight years with that company, he turned from operation to equipment sales and joined Dorr Co. where he became manager of their central div. in charge of the Chicago office. He is now in the Stamford, Conn. office.

Mr. Counselman joined the AIME in 1914 and since then has been constantly active in its behalf. He was Chairman of the Chicago Section, Chairman of the Milling Methods Committee, and was largely instrumental in the later transmutation of that committee into the present Minerals Beneficiation Div. He was chairman of the committee which raised the fund for the Richards Award. He is currently a member of the Richards Award Committee and has been a member of the Douglas Medal Committee. At one time he was Vice-Chairman of the Blast Furnace Coke Oven and Raw Materials Committee of the Iron and Steel Div. After coming to New York, he became Chairman of the New York Section, thus having the distinction of being past Chairman of two AIME Sections. He served for several years on the Admissions Committee; and when the Council of Section Delegates was reorganized on a more permanent basis in 1950, he became the first Secretary of the Council. He is currently Chairman of the national Membership Committee.

Thomas L. Joseph has been nominated Director of AIME to serve from 1952 to 1955. As Chairman of the Iron and Steel Div., he is currently a member of the Board of Directors, ex officio. Mr. Joseph was born in Adamsville, Utah, in 1894 and graduated in 1917 from the University of Utah with an M.A. degree. He was with the Ordnance Dept. of the U.S. Army during World War I, and later employed by the U. S. Bureau of Mines at its North Central Experiment Station in Minneapolis. In 1936, Mr. Joseph resigned from the Bureau of Mines to become head of the dept. of metallurgy, Minnesota School of Mines and Metallurgy, where he is now assistant dean of the Institute of Technology. Mr. Joseph is the author of numerous papers on iron ore, sinter, metallurgical coke, and various phases of the blast-furnace process. During World War II he was a member of the War Metallurgy Committee on which he planned and supervised a project designed to increase the output and efficiency of blast furnaces. In 1927 Mr. Joseph was the recipient of the J. E. Johnson, Jr. Award; he received the Richard W. Hunt Medal and Prize in 1937, and was Howe Lecturer for 1946.

Carl Ernest Reistle, Jr. has been nominated Director of AIME for a three-year term beginning February 1952. He was born at Denver in 1901 and graduated from the University of Oklahoma in 1922 with a B.S. in chemical engineering. Following graduation he worked as a petroleum chemist for the U. S. Bureau of Mines at Bartlesville, Okla. and later at Laramie, Wyo., where he was also an honorary member of the faculty at the University of Wyoming. He returned to Bartlesville in 1929 and remained with the Bureau of Mines until 1933 when he became Chairman of the East Texas Engineering Assn. It was through the cooperative efforts of member companies of this association that many of the conservation rules and regulations of the Railroad Commission were perfected. In 1936 Mr. Reistle joined Humble Oil & Refining Co., in 1948 was elected a member of the board of that company and is at present director in charge of the production dept.

During World War II, Mr. Reistle served as technical adviser for District III of the Petroleum Administration for War and also served the Office of Price Administration as national vice-chairman of the Oil Industry Advisory Committee. He is the author of numerous papers, several of which have been published by AIME, and has been issued a number of patents.

Mining Branch Divisions' Programs

Headline AIME October Meeting at Mexico City

EXCEPT for listing the papers to be presented, the program for the AIME Fall Meeting, in Mexico City, beginning Monday, October 29, can now be given in some detail. It promises to be the most enjoyable meeting the Institute has ever staged, and an experience that those who attend will never forget. A total of 800 hotel rooms with accommodations for close to 1500 people have been definitely reserved.

It will be a joint meeting with the Pan-American Institute of Mining Engineering and Geology (its third congress) and the Instituto Nacional para la Investigacion de Recurses Minerales, of Mexico, whose director general, Raul de la Pena, first issued the invitation to the AIME, early in 1950.

Monday morning at 10 am the opening sessions will be held, followed by an official banquet at 1 pm. Later in the afternoon trips to places of interest in the city are scheduled: National Palace, Metropolitan Cathedral, Museum of Archeology, Central Post Office, Chapultepec Castle, and residential zones. At 9 pm will be staged what we are assured will be the social highlight of the meeting—"Mexican Gala Night"—an exhibition of regional dances and costumes by representatives of the 52 Indian tribes of Mexico.

Tuesday morning and afternoon, and again on Wednesday morning and afternoon, there will be technical sessions, both of the AIME and the other two groups. The Mining, Geology, and Geophysics Div. and the Minerals Beneficiation Div. of AIME will have programs of four sessions, with a somewhat less extensive program in prospect for the Industrial Minerals Div., and the Mineral Industry Education Div. The Society of Economic Geologists is sponsoring several papers on the MGGD program. The technical program will be published in the August issue of MINING ENGINEERING.

Tuesday night a special AIME party for ladies and gentlemen is being arranged, and Wednesday night there will be a supper and dance at "El Patio" night club. This promises to be the only event at which ladies will wear long dresses and some of the men, at least, will appear in black or white dinner jackets. Sport clothes and ordinary suits will be in order for all other events.

Thursday morning there will be a choice of two short trips: (1) One of scenic and historical interest to the so-called Desert of the Lions, with a visit to the University City, Copilco archeological site, and Cuicuilco Pyramid; or (2) To Tenayuca Pyramid and Tepozotlan Monastery. At 2 pm a luncheon at Xochimilco is planned, with a boat ride on the famous canals and through the floating gardens.

Friday will be taken up by a trip to Taxco for a visit to the mining district and to the silver manufactories. The American Smelting & Refining Co. will tender a luncheon to the visitors. The party will return to Mexico City for the night and the next day, Saturday, will be spent at Pachuca, where the famous silver mining operations will be visited. Luncheon here will be offered by the Cia. Real del Monte y Pachuca. Those who do not wish to go to Pachuca can, if they wish, begin a three-day trip to Guanajuato where, on Sunday, they will visit the Guanajuato mining district and be guests of the Governor of the State of Guanajuato for luncheon. They will stay there overnight and return to Mexico City on Monday, November 5. Those who do not go to Guanajuato will spend Sunday in Mexico City where a special trip will be arranged to the San Juan Teotihuacan archeological zone and to the Acolman Monastery in the morning; there will be bull fights in the afternoon.

For those who can spend three more days, four four-day trips have been arranged, beginning Sunday morning. No. 1 includes Taxco and Acapulco for those who want to see a bit of the Pacific seashore. No. 2 goes west to Morelia, Patzcuaro, Uruapan, the Paricutin volcano, and San Jose Purua. Trip No. 3 will be to the southeast and the Gulf Coast, visiting Puebla, Tehuacan, Orizaba, Fortin de las Flores, Cordoba, and Veracruz. No. 4 will go down to Oaxaca, visiting the archeological ruins of Mitla and Monte Alban.

AIME headquarters for registration will be at the Hotel del Prado, but most technical sessions will be in the Sala Manuel M. Ponce in the Palace of Fine Arts. Across the street from the Prado is another fine hotel, the Regis, and there are two other top-ranking hotels, the Reforma and Geneve from five to ten blocks away. The number of rooms reserved at these four hotels is, respectively, 100, 81, 75, and 75. At eighteen other hotels, all well recommended, a total of 470 rooms have been reserved. Some of these smaller hotels may appeal more to some of the visitors than the large hotels. Mexico City is about the size of Detroit or Los Angeles, with a population of 1,750,000, and the entertaining of guests is one of its specialties, so plenty of good hotels are available. Although the Del Prado will be considered AIME headquarters, no technical sessions and no social events will be held there, so any other hotel will be equally as convenient for all purposes except registration.

A well-established and bonded organization, Aguirre's Guest Tours, S.A., Av. 5 de Mayo No. 18, Mexico 1, D. F., is handling all arrangements for transportation and hotel accommodations. An over-all price has been set up to include the following services: (1) Transportation from airport or railroad station to hotel; (2) Transportation from the Palacio de las Bellas Artes to the Casino Militar where the Governor of the Federal District plans to give the official luncheon banquet on Monday, followed by sightseeing trips

Mr. William G. Kane
San Juan de Letran 9, Room 805
Mexico, 1, D.F.

Please make the following reservations for me for the October meeting:

Single Room ..... Double Room with twin ..... double ..... beds, at about $..... per day. (Single, $3.50 to $8; double, $4.50 to $8.50.) There will be ..... men and ..... ladies in my party. Expected date of arrival .....; departure .....

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throughout the city, all included in the price; (3) Admission to the Mexican Gala Show; (4) Dinner and dance at El Patio night club with special floor show; (5) Round trip to Xochimilco including banquet luncheon; and (6) Seven days' lodging at the best hotels in the city in single or double rooms with double or twin beds. The over-all price for these six items is $79 per person. If a somewhat less luxurious hotel is desired the price will be $72; or if a still less expensive hotel, $66. In every case the best rooms in the hotel will be provided. Those wishing suites will, of course, have to pay a bit more.

For $44 extra, meals will be provided in addition for the seven days, including the choicest offerings of 23 of the best restaurants in the city. Inasmuch as several free meals will be provided, however, this may not be so attractive.

Prices of everything except imported merchandise is said to be about half that in the United States. Tourists are particularly attracted by the peasant type of blouses and skirts; alligator leather handbags, bags of tooled leather and a variety of belts; shoes, excellent and modern, of alligator, snakeskin, and fine tanned leather; silverware; necklaces and bracelets; pottery and tile; French perfume. All just in time to buy your Christmas presents. Fixed prices in the large city stores but bargaining is usual in the smaller towns and shops. Exchange is fixed at 8.60 pesos for $1, or 11c to the peso. There is no black market; money may be exchanged from dollars to pesos or vice versa in unlimited amounts in practically any store, bank, or hotel.

Motoring to Mexico City is simple. Allow two days from the border; from Laredo or El Paso; the former the most scenic. More details on the motor trip will be given in a later article. In the meantime read "Mexico With a Car" on page 94 of the May *Atlantic* (offset copies available free from the Secretary of the AIME, New York) or see a 200-page booklet published by the American Automobile Assn. for its members, with detailed road maps and every conceivable bit of information you may wish to have to visit the country, including even a short course in Spanish.

The Missouri Pacific runs a modern streamliner to Mexico City from St. Louis in two days. The Southern Pacific has a good train from Los Angeles in a little less than 3 days, and from El Paso one can get down in a little less than two days. American Airlines has excellent service from various U. S. points. If you are planning to fly to Los Angeles for the Mining Congress meeting Oct. 22-24, and the fall Southern California Section meeting Oct. 25-26, you can make a side trip by American Airlines to Mexico City the next week for only $59. The information requested on the coupon below should give the Secretary of the Mexico Section some idea of how many plan to come to the meeting by rail and air. Special cars or planes may be arranged if the groups are large enough.

What to Do

If you are merely *thinking* of coming to the meeting, this is what you should do. Write to William G. Kane, San Juan de Letran 9, Room 805, Mexico 1, D. F., and tell him to send you all literature and keep you advised of plans. Or if you have definitely decided to come to the meeting, fill out the coupon below and send it in. In either case, you will shortly receive full information from Aguirre's Guest Tours about hotel reservations and other pertinent matters. You will probably then wish to send a check for $66, $72, or $79, depend. upon the hotel accommodations you wish, for each person in your party, whereupon your room for seven days at the meeting is definitely assigned and paid for and you will have no further worry about it. Other social events you will wish to attend are also paid for to the extent already indicated. If your plans change at the last minute, wire or write to Aguirre and your money will be refunded.

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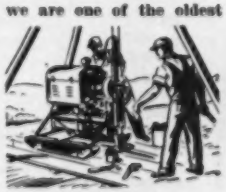

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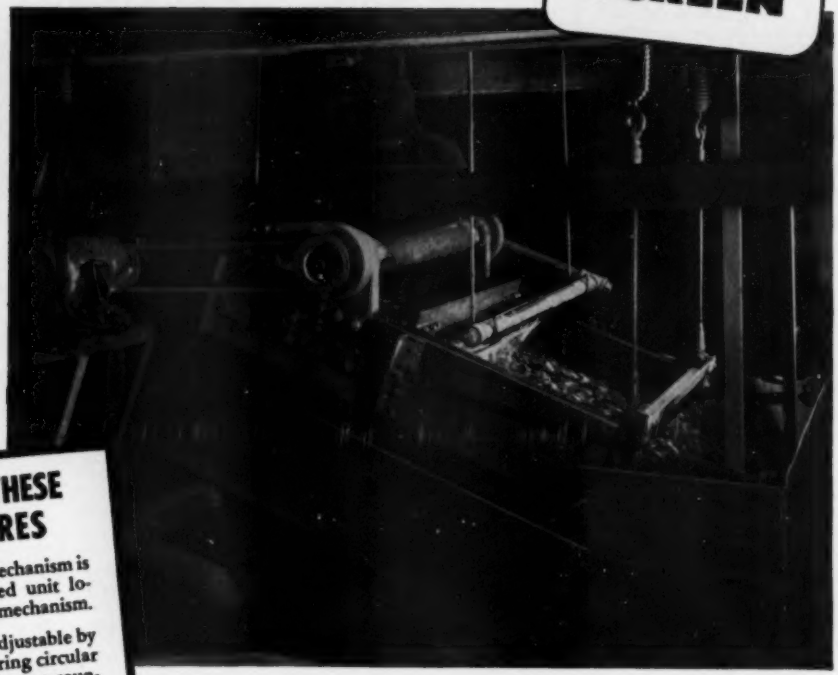

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- Vibrating mechanism is self-contained unit located above mechanism.
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- Easy to remove vibrating mechanism — remove only eight bolts.
- True running drive — screen sheave does not vibrate with screen.
- Sizes 2 x 4 to 5 x 10 ft. Open or enclosed. 1 to 3 decks.

LOW FIRST COST plus low operating costs — no wonder mining men have found this vibrating screen profitable for screening or rinsing a variety of ores.

Simple two-bearing Allis-Chalmers design has fewer parts, resulting in easy maintenance and low power costs. *Aero-Vibe* screens are built sturdily — they deliver a top-notch job of screening year after year despite tough-going service.

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Drift of Things . . . . . as followed by **Edward H. Robie**

IN the employment situation for professional men in the mineral technology field, the pendulum seems to swing rapidly and far. Less than a year ago more men were seeking jobs than there were openings available. This was particularly true of young men and inexperienced college graduates. Just the reverse is now true. The Engineering Societies Personnel Service reports that it recently has been able to find men for only 7 pct of the openings that it has available. In more normal times the figure is 35 or 40 pct. Those who might be interested in considering another job, therefore, might find it to their advantage to register with the Personnel Service. Also, they would thereby make it possible for the Service to do a better job in filling requests from employers.

The Personnel Service has four offices. One should register with the office that serves the area in which a job would be most attractive. Registration with more than one office is permissible. Western mining and oil men would naturally clear through the San Francisco office; most metallurgists through one of the Eastern or Mid-Western offices. The addresses are: 8 W. 40th St., New York 18; 100 Farnsworth Ave., Detroit; 84 E. Randolph St., Chicago 1; and 57 Post St., San Francisco. There is no charge for registration—only if a job is secured. The fee for AIME members is one week's salary for jobs paying less than $3000 a year, ranging up to 3¾ pct of annual salary for jobs paying $5000 or more. A registrant is kept on the active list for 2 months. If a job is not obtained in that time, he may on request be kept on the active list longer. If a job is offered but not accepted there is no charge.

All jobs are coded, so no publicity is given to a registrant except to the potential employer to whom the registrant is referred and who has asked for a man with his type of experience.

Bargain for New Junior Members

Never before, we believe, have newly elected Junior Members of the AIME received such a bargain. Graduating Student Associates are being given a special incentive to change their status to Junior Membership, and young men out in the industry, not over 30 years old, who are not yet members will probably never have a better incentive to apply.

Beginning with elections in June 1951, all new Junior Members are privileged to receive a copy of the immensely popular reprint of *"Agricola,"* some 2500 copies of which have been ordered by AIME members since the volume was issued early last December. The stock was soon exhausted but more are now available. This is a $10 book, with no discount permitted. The Institute, however, has purchased through money made available by the Seeley W. Mudd Memorial Fund 1400 copies for gratis distribution to new Junior Members. Also they automatically receive a copy of *"A Professional Guide for Junior Engineers"* and their choice of one of seven other volumes ranging in price from $1.50 to $5. If their interests happen to be in petroleum, they also receive a fourth free volume, listed at $2.50, on the legal aspects of the unit operation of oil pools. Thus, for the initial year's dues of $12, (there is no initiation fee) a Junior Member receives a year's subscription to the journal of his choice and up to $18.50 worth of books.

The opportunity to purchase books at special prices is an advantage that all members receive, but is not always realized. Books published by one of the Institute's Funds are available to members at approximately half the price that a commercial publisher would place on a similar book. Also, AIME members are granted a 10 pct discount on a wide variety of other publishers' books. For those who keep their libraries up to date and well stocked, the savings thus possible may well offset the annual dues.

Transactions Volumes

The AIME has a surplus stock of certain Transactions volumes issued prior to 1928 that it will sell at cutrate prices. Normally these sell at $5, less 30 pct to AIME members, for the leather-bound editions. Until Aug. 1, orders will be accepted for the available leather-bound copies at $2.25, and for the paper-bound copies at $1 each. The leather in many of these books is not in good condition, and the paper-bound volumes are discolored and soiled, so the books are sold *"as is."* If pages are found missing or the print is illegible, however, refund will be made.

Leather-bound volumes are available of all volumes from No. 2 to No. 76 inclusive except Nos. 5, 8, 9, 18, 64, 69, 72, and 73. Paper-bound copies are available of all except Nos. 5, 8, 9, 22, 28, 31, 37, 39, 41, 45, 50, 58, 62, 63, 67, 68, 74, and 76. Orders are subject to prior sale.

Here's a chance possibly to complete your library. Or merely to buy a book or two for a nominal price and see what the experts believed 25, 50, or 75 years ago.

Bless His Heart

It has been said that even when business is sound, the sound is mostly complaint. Human beings are much more likely to complain about something they do not like than to give thanks for what they do like. Most everybody seems to consider perfection a matter of course. So a normal number of expressions of dissatisfaction with the activities of any organization are to be expected. But something drastic should be done if the complaints are numerous or if they indicate remediable faults.

Complaint letters received by the AIME are by no means numerous, but occasionally a member does have just cause for resentment, and sometimes two or three just causes.

All of which is leading up to a letter we received on Apr. 23 from a petroleum engineer at the University of Texas—a Junior Member. "The purpose of this letter", he says, "is not to offer a sad tale of woe, nor to mention my 'sad neglect', but rather to express my sincere appreciation for a job well done. In the past I have found it comparatively easy to complain of a situation but more difficult to give credit where credit is due. So as not to fall into the category of a 'complainer', I want to take this opportunity to thank you for the manner in which you handled my letter of Apr. 6. It is my hope that the Institute will continue to have competent personnel in its offices to straighten out little mixups that will always occur in an organization as large as ours. Thanks a million—"

Needless to say the staff member who handled this particular transaction was set up no end when she received this praise. If she has her way, the young man who wrote this letter will have preferred treatment at Institute headquarters for a long time to come.

Personals

Sumner M. Anderson, chief, Latin American Div., Foreign Minerals Region, Bureau of Mines is now in Bolivia working on problems relating to Point IV assistance in tin metallurgy.

Wayne Ahl is now located at the Sherwood iron mine, Iron River, Mich., as engineer for the Inland Steel Co.

W. G. Boggs has joined the Rhokana Corp., Kitive, Northern Rhodesia.

K. A. Bath is with the Fresnillo Co., Fresnillo, Zacatecas, Mexico.

Benson D. Blackie is working in a trainee program for United Geophysical Co., Inc., Santa Paula, Calif.

James M. Birkbeck, Cerro de Pasco Copper Corp., is now located at Lima, Peru.

Alberto Enrique Brazzini is in Washington, D. C. as Peruvian delegate to the International Material Conference, Copper, Lead, Zinc Committee.

Otto Barth of the Royal Institute of Technology, Stockholm was recently in Turkey to start the new smelter of the Murgul Bakir Isletmesi (Murgul copper works) controlled by Etibank, Ankara.

E. L. Bemis, superintendent of the Canisteo mine, Cleveland-Cliffs Iron Co., Coleraine, Minn., has resigned his position due to ill health and will be associated with Craigmyle, Pinney & Co., Winter Park, Fla. **Jack Chisholm,** who was assistant superintendent, is now acting superintendent.

William M. Campbell is now associated with the Quemont Mining Corp., Ltd., Noranda, Que.

Bimson McLeod Crouse has been employed as mine foreman by the Australian Blue Asbestos Co., Whittenoom Gorge, Western Australia.

Carl F. Clausen, manager of manufacturing research for the Portland Cement Assn. of Chicago, has been named consultant in the Building Materials Div. of NPA's facilities and construction bureau.

Clinton H. Crane has been reelected chairman of the board, St. Joseph Lead Co., New York. **Andrew Fletcher** was reelected president; **C. Merril Chapin, Jr.,** vice-president; **Francis Cameron,** vice-president; **George I. Brigden,** vice-president and treasurer; and **Felix E. Wormser,** vice-president. **Charles R. Ince** and **Rene J. Mechin** have been elected vice-presidents.

John Ahearn Cronin is now employed as a testing engineer by the Inspiration Consolidated Copper Co., Inspiration, Ariz.

Everette L. DeGolyer, senior partner, De Golyer & MacNaughton, Dallas, and **Frederick Seitz,** research professor of physics at the University of Illinois, Urbana, Ill., have been elected to membership in the National Academy of Sciences.

Jerome J. Daly has become associated with Copco Pacific Ltd., San Francisco.

C. B. E. Douglas has retired after 23 years with the U. S. Smelting, Refining & Mining Co. and its subsidiaries. He joined the company as field engineer, and was then superintendent of the Mexican subsidiary, sub-director of the Compania Real del Monte y Pachuca, and consulting mining engineer, respectively. He will reside at Wellesley Hills, Mass. and after a few months' vacation may do some consulting work.

Donald A. Damkroger is now with the Andes Copper Mining Co., Chanaral, Chile.

Ronald W. Durdin has joined the Zinc Corp., Ltd., Broken Hill, N. S. W., Australia, as cadet engineer.

B. F. Eads, University of Kentucky College of Engineering, has been named winner of the Old Timers' award made to the school's outstanding student of mining engineering.

L. W. EASTWOOD

L. W. Eastwood has accepted the position of assistant director of metallurgical research, Kaiser Aluminum & Chemical Corp., Spokane, Wash. He had been a member of the staff at Battelle Memorial Institute.

Joseph R. Engott is shop superintendent, Truax-Traer Coal Co., Kayford, W. Va.

Arol W. Estey, geologist, has joined Cochenour Willons Gold Mines, Cochenour, Ont.

P. C. Emrath, mining engineer, Marion, Ky., is leaving for Taiwan (Formosa) for the J. G. White Engineering Corp., New York. He will be examining and rehabilitating a number of mining operations, including coal and metallic minerals.

Hugh W. Evans has been recalled to active duty with the U. S. Army and is presently located at Monterey, Calif.

Wallace G. Fetzer has been made chief geologist, western div., Vanadium Corp. of America, Durango, Colo.

Michael P. Fominyh is now geologist with the Denver Equipment Co., Denver.

T. G. Gerow, formerly executive vice-president, Truax-Traer Coal Co., Chicago, has resigned to become president of the West Virginia Coal & Coke Corp., Cincinnati.

Donald P. Gray has become assistant engineer for the U. S. Gypsum Co., Plaster City, Calif.

Gus H. Doudarzi is now with the Geological Survey of Gold Coast, Saltpond, Gold Coast, Africa.

Michael J. Gleason has been appointed assistant manager of contract drilling for E. J. Longyear Mining Co., Minneapolis.

R. K. Gottshall was elected a vice-president of Atlas Powder Co., Wilmington. He had been assistant to the president.

William H. Hisle has resigned as assistant general superintendent, Deep Mines Operation, Goldfield, Nev., and is now general manager, McLaren Gold Mines Co., Cooke, Mont.

W. Church Holmes has joined the Fluor Corp. Ltd., Los Angeles.

Pedro Horna Moreno, chief mining engineer, Northern Peru Mining & Smelting Co., has been transferred from Toquepala to Quiruvilca, Peru.

Charles E. Hunter is geologist, Consolidated Feldspar Corp., Asheville, N. C.

Walter George Harper has been appointed divisional coal preparation engineer, National Coal Board, northeastern div., Doncaster, Yorkshire, England.

Charles Von Oden Hughes, Jr. has joined the Virginia-Carolina Chemi-

cal Corp., Florida dept., phosphate mining div., Fort Meade, Fla. For the past 10 years he has been located on the west coast.

Fred J. Hoff, Lakeland, Fla., is now with the Lepanto Consolidated Mining Co., Philippines.

Robert M. House, American Rock Wool Corp., was promoted from assistant plant manager, Torrance, Calif., to plant manager of the Birmingham plant.

J. A. HOAGLAND

J. A. Hoagland, Drilling & Exploration Co., Inc., Belem, Brazil, is now located in Tucson, Ariz.

H. F. Haller has resigned his position as assistant mining captain at the Sunday Lake mine, Wakefield, Mich., to accept an appointment as assistant to the superintendent of the Southern Alkili Corp.'s limestone mine at Barberton, Ohio.

Frederick L. Knouse has been working for the Defense Minerals Administration, production expansion div. as mining engineer contract negotiator.

Arthur D. Kellogg has accepted a position with the N. J. Zinc Co., at Austinville, Va.

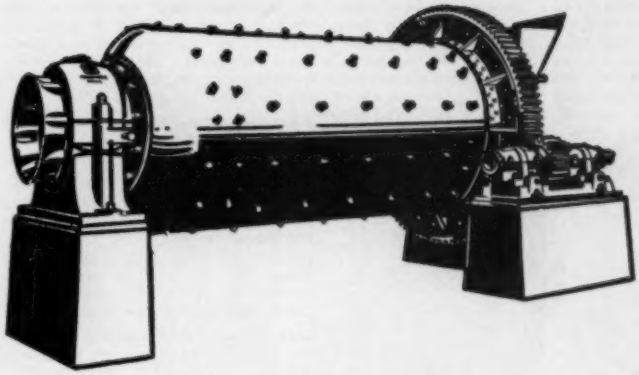
Toshio Katsuki is now manager, Kune copper mine, Furukawa Mining Co., Shizuoka-Ken, Japan.

James L. Lane, formerly engineer, Idarado Mining Co., Ouray, Colo. is on active duty with the U. S. Army. He is presently serving as a construction engineer, Yokohama, Japan.

Paul B. Leavenworth has joined the Housh Drilling Co., Houston, as manager of exploration. He was formerly chief geologist for the Houston district of Gulf Oil Corp.

D. Keith Lupton recently joined the N. J. Zinc Co., Austinville, Va. as a geologist.

Roger W. Loveless has become mill superintendent for the Cia Minera Nacional S.A., Presidio, Texas.



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TECHNICAL BULLETIN ON . . .

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The controversial issue of "when to use Rod Mills" is thoroughly discussed in this new Hardinge Bulletin (No. 25-C-2). It includes much "meaty" information on the general subject of rod milling and the proper field of application for Rod Mills.

Specific details of Hardinge Rod Mill construction, sizes, and other specifications are, of course, included.

Write for your copy today.

At the right is an interior view of the largest Rod Mill in existence — an 11½′ diameter Hardinge Rod Mill—showing lifter-bar lining and rods.

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James E. Lee has been made assistant mill superintendent for the International Nickel Co. of Canada, Ltd., Copper Cliff, Ont. He had been general foreman, concentrator research dept.

WM. D. LORD, JR.

William D. Lord, Jr. has been appointed general manager of mines, International Mining Co., La Paz, Bolivia. He succeeds **George D. Bellows** who has resigned to return to the United States.

Roland W. Merwin, metallurgist, has joined Neptune Gold Mining Co., Managua, Nicaragua.

S. Frederick Magis was elected general manager of the Siderurgica Venezolana "Silvensa" S. A., Caracas, Venezuela. He was formerly consultant on production of steel and finished steel products.

Charles E. Melbye has resigned from Anaconda Copper Mining Co., Tecopa, Calif. He is now mining engineer with Telluride Mines, Inc., Telluride, Colo.

Ralph J. Magri, Jr., has become development engineer for Calco div., American Cyanamid Co., Piney River, Va. He was formerly associated with Corhart Refractories Co., Louisville, as research engineer.

Richard A. Matuszeski has accepted the position of extraction metallurgist in the tungsten and chemical div., Sylvania Electric Products, Inc., Towanda, Pa. He had been metallurgist and chemist-assayer, New Mexico Bureau of Mines & Mineral Resources, Socorro, N. Mex.

Dale C. Matthews, formerly general superintendent of Benjamine Franklin Graphite Co., Chester Springs, Pa., is now general superintendent of the Galigher Co., Monticello, Utah, AEC contract operations.

Plato Malozemoff has been elected to the board of directors of Sherrit Gordon Mines, Canada.

Baltazar Martinez has been promoted to assistant superintendent, by-products plant, Compania Carbonifera de Sabinas, S. A., Coahuila, Mexico.

Charles S. Merriam has been assigned to the Office of the Unit Instructor, U. S. Army Organized Reserve Corps, Little Rock, Ark.

RICHMOND E. MYERS

Richmond E. Myers has accepted a position as geologist with the Pennsylvania Water & Power Co. of Baltimore. He had been associated with the geology dept., Muhlenberg College, Allentown, Pa.

James Frederick Olk is now employed as a mining engineer by the M. A. Hanna Co., Hibbing, Minn.

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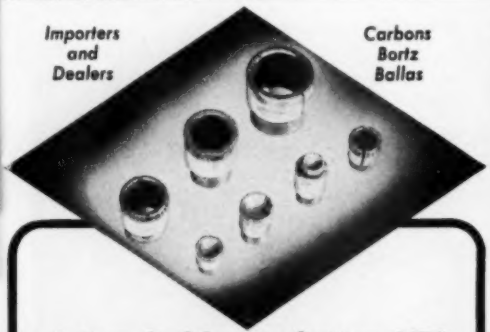

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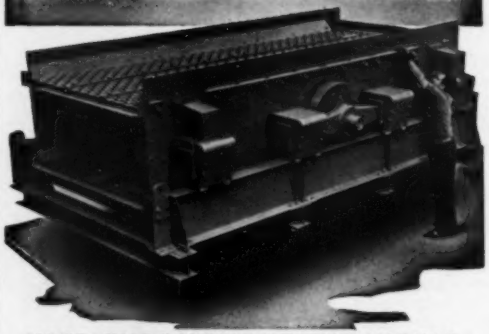

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Nikit Ordjanian has resigned as assistant to the president and secretary, Laurent Industrial Development Co., Inc., New York. He has become vice-president, General Industrial Development Corp., New York. Mr. Ordjanian is presently in Germany and France.

M. J. O'Shaughnessy has joined the Quebec Iron & Titanium Corp., Sorel, P. Q.

Willis McG. Peirce, 1951 President of AIME, is now located at the New York office of N. J. Zinc Co. Mr. Peirce had previously been at Palmerton, Pa.

Joseph Pickering, mill operator, Volo Mining Co., is now located at Placerville, Calif.

Norman P. Proehl, formerly with Fairbanks Exploration Co., is now superintendent of the Livengood gold dredge property near Fairbanks, Alaska.

Rex F. Pearce has resigned from the Rhokana Corp., Northern Rhodesia and has joined the South African Cyanamid, Pty., Ltd., Johannesburg.

John Alan Riley is president and general manager of the Colombian Development Corp., New York.

P. H. Reagan, consulting mining engineer of Hye, Texas, is now in Australia.

D. G. Runner, formerly a commodity specialist in the construction and chemical materials branch, Bureau of Mines, has accepted the position as chief of the cement and cement products section, building materials div., NPA, Washington, D. C.

Albert Reilingh has joined the Cia Huanchaca de Bolivia, Uyuni Est, Bolivia. He had been employed by the Liberia Mining Co., Monrovia, Liberia.

O. A. Rockwell, general manager of the Calumet div., Calumet & Hecla Consolidated Copper Co., has been elected a vice-president.

Guy Riddell has returned to his offices at Royal Oak, Md., and Washington, D. C. after lode and placer examinations in Nevada, Arizona, and California. He has completed a consultant assignment for the Bureau of Mines on one of the strategic ores and metals now in short supply. A co-founder of Senior Consultants, Inc., New York, his Washington headquarters are with Charles H. Upham & Associates. He may be contacted through the Engineers' Club, New York since much of his time is spent between New York and the west coast.

V. Subramaniam is now chief cost accounts officer, Finance Ministry, Government of India, New Delhi, India.

James W. Smiley has joined the Macco Corp., Craig, Colo., as service engineer.

JOSIAH THOMAS

Josiah Thomas has resigned as manager of the Bolivian subsidiary companies, American Smelting & Refining Co. and has accepted the position of general manager, Cia. Minera Unificada del Cerro de Potosi, Potosi, Bolivia.

J. Van de Velde has become head, mining research dept., S. A. Belgometal, Brussels, Belgium.

Leland C. Vought is now employed as a geologist for United Geophysical Co., Inc., Tucson, Ariz.

J. Verdussen, Union Miniere du Haut-Katanga, Brussels, Belgium, was appointed a representative of Engineers' Joint Council.

M. H. Van Ornum, mine superintendent, U. S. Gypsum Co., has been transferred to Chicago from Plasterco, Va.

Edward W. Witcomb is now assistant concentrator superintendent, Chile Exploration Co., Chuquicamata, Chile.

Donald W. Winsor has joined the Anaconda Copper Mining Co., Butte.

Stanley M. Walker has been made acting chief, housing utilities branch, requirements div., Defense Minerals Administration, Washington, D. C.

George W. Wunder, plant manager of National Lead Co.'s MacIntyre development, has been appointed plant manager of the AEC's Feed Materials Production Center planned for construction near Cincinnati. National Lead Co. is contract-operator of the plant.

Elton A. Youngberg is now mining engineer, U. S. Geological Survey, Spokane, Wash.

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Obituaries

Henry C. Howarth

An Appreciation by H. P. Greenwald

Henry C. Howarth (Member 1938), a mining engineer and employee of the Bureau of Mines for 40 years, died at Pittsburgh on Feb. 18, 1951, at the age of 71. Born at Bolton in Lancashire, England, he was brought to this country by his parents when less than two years old. He worked in several coal mines in western Pennsylvania prior to joining the staff of the Bureau of Mines in December of 1910 as mine foreman. Under direction of the late George S. Rice he developed the Bureau's Experimental coal mine near Bruceton, Pa. Advancing to superintendent and mining engineer he was identified with all work conducted in the mine until his retirement at the close of 1949. Because of wide knowledge of mine fire behavior he was subsequently placed on the Bureau's staff working on control of fires in inactive coal deposits.

Mr. Howarth combined sound judgment with the capacity to get things done. His ability to weld a group of men into a smoothly working team was outstanding. The amount and quality of large-scale experimental work accomplished in the experimental coal mine over the years resulted in no small measure from his painstaking attention to the accuracy of preparation of the numerous interlocking procedures required for preparation of each test and to the primary analysis of test data. His untiring efforts were an important factor in acquirement of knowledge concerning coal dust explosions. Together with the conduct of demonstrations for the public they must be recognized as an important factor in the reduction of coal dust explosions in mines from frequent disasters "beyond man's control" to a rarity and an event that can claim no right of toleration.

HENRY C. HOWARTH

W. G. Mather (Member 1886), honorary chairman of the Cleveland-Cliffs Iron Co., died on Apr. 5, 1951, after several weeks of illness. Mr. Mather was born at Cleveland in 1857. He studied at Cheshire Academy, Cheshire, Conn., later matriculating in Trinity College, Hartford where he took his B.A. in 1877 and his M.A. in 1880. In 1878 he entered the employ of the Cleveland-Cliffs Iron Mining Co. as a clerk. He later became assistant secretary and then vice-president. When his father died in 1890, Mr. Mather assumed the presidency of the firm. Cleveland Iron Mining Co. merged with the Iron Cliffs Co. in 1891 and he was made president of the new corporation. He continued in this position for 42 years, until 1933 when he was elected chairman of the board of directors. In 1947 he became honorary chairman. He was also a director in several other companies.

George E. Addy (Member 1946) died on Sept. 24, 1950. Mr. Addy was born at Coalville, Utah in 1889 and attended the Universities of Wyoming and Utah. In 1926 he joined the Utah Delaware mine, Bingham Canyon, Utah and remained with this company for approximately 11 years as foreman. He joined the National Tunnel & Mines Co., Bingham Canyon as foreman and was employed by them at the time of his death.

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FLEXCO HINGED
BELT FASTENERS
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For joining underground extension conveyors.
A FLEXCO fastener that is HINGED. Has removable hinge pin.
Troughs naturally, operates smoothly through take-up pulleys.
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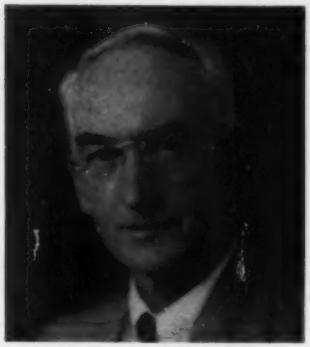
4629 Lexington St., Chicago 44, Ill.

C. T. Griswold (Member 1907), consulting geologist and mining engineer of Albuquerque, N. Mex., died Mar. 22, 1951. He was born in South Cortland, N. Y. on Sept. 12, 1877. He graduated from Amherst College in



C. T. GRISWOLD

1903 and from the Columbia School of Mines in 1905. Mr. Griswold was professor of mining at Colorado College from 1907 to 1910 and at Carnegie Institute of Technology from 1910 to 1914. He was active in geological exploration in Oklahoma and Texas during the early days of the oil industry. From 1917 to 1932 Mr. Griswold was mining engineer for the AT&S Railroad Co. In 1933 he established a consulting office in Albuquerque. During World War II he was general manager of the Pumice Corp. of America operations at Grants, N. Mex. His latest projects were detailed geologic mapping of the Ortiz mine grant in Santa Fe County, N. Mex. and consultation work on the recent uranium discovery near Grants.

Emmet F. Meyerhoff (Member 1928), Rocky Mountain member, has died. He was residing at Van Nuys, Calif. at the time of his death.

NECROLOGY

Date Elected	Name	Date of Death
1937	H. H. Burhans	Unknown
1934	James L. Leonard	May 5, 1951
1949	C. O. Penney, Jr.	November 1950
1944	Joseph Pursglove, Sr.	Apr. 24, 1951
1889	F. F. Sharpless	Apr. 11, 1951
1945	Ray E. Tower	Unknown

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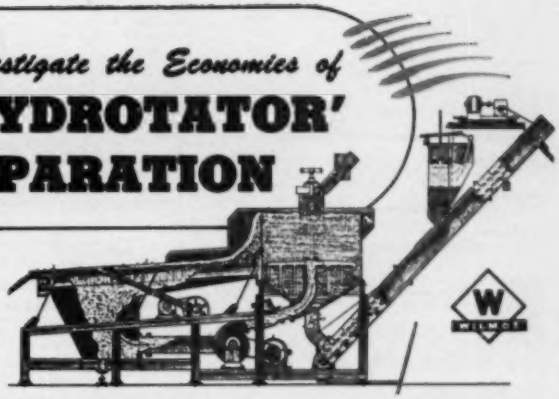

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Institute members are urged to review this list as soon as the issue is received and immediately write the Secretary's Office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified. Objections must be received before the 30th of the month on Metals and Mining Branches.

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Tiger—Snodgrass, James E. (M)
Tiger—Wood, Homer E. (M)

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San Francisco—Simpson, John D. (M)
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Colorado
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— Coming Events —

July 1-7, Iron Ore Centennial, Iron River, Mich.

July 2, AIME, Pennsylvania Anthracite Section, dinner-dance, Scranton Country Club, Scranton, Pa.

July 5-11, National Management Council, International Management Congress, Brussels, Belgium.

July 9-11, Idaho Mining Assn., annual convention, Sun Valley, Idaho.

July 30-Aug. 2, American Electroplaters' Society, Statler Hotel, Buffalo.

Aug. 7, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Aug. 27-Sept. 6, Oak Ridge National Laboratory and Oak Ridge Institute of Nuclear Studies, summer symposium, Oak Ridge.

Sept. 13-15, AIME, Industrial Minerals Div., fall meeting, University of West Virginia, Morgantown, W. Va.

Sept. 16-19, American Institute of Chemical Engineers, regional meeting, Sheraton Hotel, Rochester, N. Y.

Sept. 18, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Sept. 19, AIME, Carlsbad Potash Section, Riverside Country Club, Carlsbad, N. Mex.

Sept. 20, AIME, Utah Section, Newhouse Hotel, Salt Lake City.

Sept. 25-28, ASME, fall meeting, Radisson Hotel, Minneapolis.

Oct. 1-4, Assn. of Iron and Steel Engineers, annual convention, Hotel Sherman, Chicago.

Oct. 3-5, AIME, Petroleum Branch, fall meeting, Oklahoma City.

Oct. 9-12, Scientific Apparatus Makers Assn., mid-year meeting, Recorder-Controller Section, Seaview Country Club, Absecon, N. J.

Oct. 10-11, Joint Fuels Conference, AIME, Coal Div. and ASME, Fuel Section, Hotel Roanoke, Roanoke, Va.

Oct. 12, AIME, Eastern Section, Open Hearth Committee, Warwick Hotel, Philadelphia.

Oct. 15-17, AIME, Institute of Metals Div., fall meeting, Detroit-Leland Hotel, Detroit.

Oct. 15-19, National Metal Congress & Exposition, Detroit.

Oct. 18-20, National Assn. of Corrosion Engineers, south central region, Corpus Christi, Texas.

Oct. 19-20, Engineers' Council for Professional Development, annual meeting, Hotel Statler, Boston.

Oct. 22, AIME, Chicago Section, Open Hearth Committee, Phil Schmidt's, Chicago.

Oct. 22-24, American Mining Congress, Metal and Nonmetallic Mining Convention, Biltmore Hotel, Los Angeles.

Oct. 22-27, Societe Francaise de Metallurgie, congress, Paris, France.

Oct. 25-26, AIME, Los Angeles Section, fall meeting, Los Angeles.

Oct. 29-Nov. 3, AIME, fall meeting, Mexico City.

Oct. 30, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Nov. 2, AIME, Pittsburgh Local Section and Open Hearth Local Section annual off-the-record meeting, Wm. Penn Hotel, Pittsburgh.

Nov. 25-30, ASME, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Nov. 28-30, Scientific Apparatus Makers Assn., midyear meeting, industrial instrument, laboratory apparatus, laboratory equipment, optical, nautical, aeronautical, and military instrument sections, Hotel New Yorker, New York.

Dec. 2-5, American Institute of Chemical Engineers, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Dec. 6-8, AIME, Electric Furnace Steel Conference, William Penn Hotel, Pittsburgh.

Dec. 11, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Jan. 16-18, 1952, Society of Plastic Engineers, Inc., annual national technical conference, Edgewater Beach Hotel, Chicago.

Feb. 18-21, AIME, annual meeting, Hotel Statler, New York.

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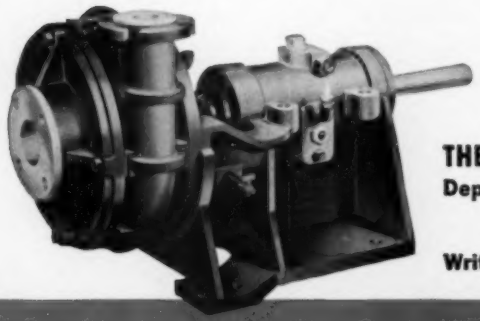

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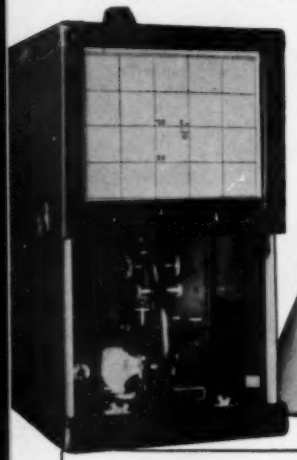
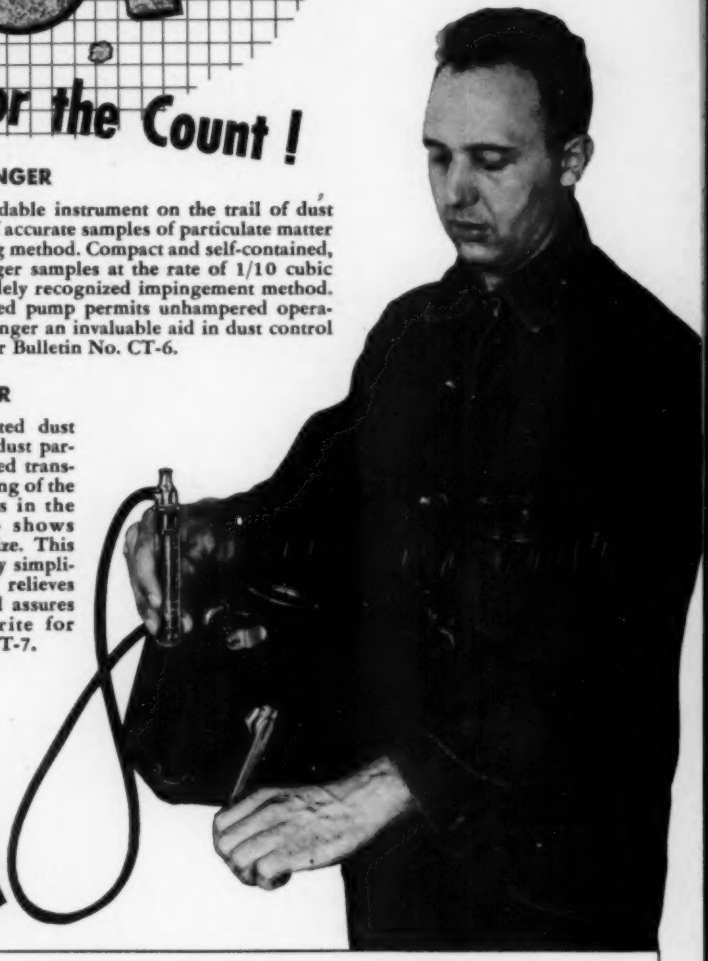
When you put this dependable instrument on the trail of dust hazards, you are assured of accurate samples of particulate matter for analysis by the counting method. Compact and self-contained, the M.S.A. Midget Impinger samples at the rate of 1/10 cubic feet per minute by the widely recognized impingement method. The integral hand operated pump permits unhampered operations. You'll find the Impinger an invaluable aid in dust control and survey work. Write for Bulletin No. CT-6.

M·S·A DUST-VUE MICROPROJECTOR

To get the story contained in the collected dust samples, the M.S.A. Microprojector shows dust particles magnified 1000 times in size on a ruled translucent screen. This permits rapid, easy counting of the dust particles in the sample—also shows the particle size. This method greatly simplifies counting, relieves eye-strain, and assures accuracy. Write for bulletin No. CT-7.





M·S·A COMPACT COMFO RESPIRATOR

Here's proved protection against harmful dusts in a compact design for maximum wearing comfort and efficiency. Twin mineral wool filters pass the air freely, but trap harmful dust particles. The dust collecting efficiency of the filters is unaffected by atmospheric conditions. Small filter holders give increased vision. Light weight molded facepiece forms soft, dust tight seal.

Write for Bulletin No. CR-26 for complete details.

MSA

SAFETY EQUIPMENT HEADQUARTERS